TITLE:MACHINE LEARNING BASED ADAPTIVE MULTIVARIATE STATISTICAL PROCESS CONTROL

Topic number : ***2021_012***

Field : Design, Industrialization

Subfield: Industrial Eng., Artificial Intelligence

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location:
Lab website:http://lcfc.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: DANTAN Jean-Yves jean-yves.dantan@ensam.eu
Advisor 2: HOMRI Lazhar lazhar.homri@ensam.eu
Advisor 3: ZOUHRI Wahb wahb.zouhri@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: The product development decision should benefit from the feedback and information provided by the users. Todays, companies are adopting “data-driven” approaches to improve the product design based on artificial intelligence tools. This enables to ensure the quality and the reliability of the product that better serve the customer in terms of availability and that basically by analysing data from the process, which are generally defined as time series.
Dynamic process control constantly drives process improvement by focusing on extracting knowledge from stored data for immediate actions, ensuring therefore more efficiency and schedule adherence. It could automatically analyse the process and send alerts for immediate improvement. By continually leading improvements, systems performance and quality are thus maximized. In fact, undefined anomalies usually result into a breakdown of the equipment or a fault in the working of the equipment. Thereby, adopting a new anomaly detection approach will lead to test’s cost reduction and allow a quick identification of anomalies and unexpected patterns. Moreover, the derived knowledge can be used to improve the product design specifications and defining its verification and validation plans to build functional and reliable models

Required background of the student: Industrial Engineering or Applied Mathematics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Ciancio V., Homri L., Dantan J.-Y., Siadat A., 2020. Towards prediction of machine failures: overview and first attempt on specific automotive industry application. IFAC-PapersOnLine 53, 289-294. 2020
2. Bassetto S., Siadat A., Martin P., Adavanced Process Control Application Modelling. CIRP Intelligent Computation Manufacturing Engineering, Jul 2002, ischia, Italy
3. Zouhri, W., Homri, L., & Dantan, J. Y. (2020). Handling the impact of feature uncertainties on SVM: A robust approach based on Sobol sensitivity analysis. To appear in Expert Systems with Applications, 2021.
4. Zouhri, W., Dantan, J. Y., Häfner, B., Eschner, N., Homri, L., Lanza, G., Theile, O. & Schäfer, M. (2020). Optical process monitoring for Laser-Powder Bed Fusion (L-PBF). CIRP Journal of Manufacturing Science and Technology, 31, 607-617
5. Himeur Y., Ghanem K., Alsalemi A., Bensaali F., Artificial intelligence-based anomaly detection of energy consumption in buildings: A review, current trends and new perspectives, Applied Energy 287, 2021.

Illustrations :

TITLE:SUPERVISED MACHINE LEARNING FOR TOLERANCE ALLOCATION

Topic number* : *2021_013

Field : Design, Industrialization, Mathematics and their applications

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://www.lcfc.fr

Contact point for this topic: Arts et Métiers

Advisor 1: DANTAN Jean-Yves jean-yves.dantan@ensam.eu
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: It is well-established that all product design activities are performed under uncertainty. Accordingly, and in light of the ever-increasing demand for high quality products and components, the topic of uncertainty has also impacted the development of tolerancing approaches. In fact, tolerancing has become the key concept for bridging the gap between design and manufacturing, not only ensuring assemblability, suitable capabilities of the required manufacturing processes and minimised costs, but also essential to ensure high and consistent behaviour of multi-physical products.
Hereby, Tolerance allocation is understood as the assignment of tolerance values according to the impact of uncertainties on product performance, and the engineering cost of uncertainty reduction vs the accuracy increase.
This proposal aims to push the frontiers of the tolerance synthesis by setting up a new methodology based on supervised learning (classification techniques) to infers the tolerance allocation model. In fact, the factor “respect of functional requirements” or “compliant product(T)” is integrated into all mathematical formulations. But the data generated to evaluate this probability “compliant product(T)” is not analyzed by machine learning techniques.
Several machine learning techniques could allow to determine a

surrogate model of the conformity product hull based on the data generated by statistical tolerance analysis. We defined the mathematical formulation of the conformity product hull: the necessary and optimal constraints on deviations of each product component, and we developed several statistical techniques to estimate the conformity product probability. The next step is to develop or to adapt several machine learning techniques to predict the product conformity hull, not for tolerance analysis, for tolerance allocation.

Required background of the student: Mech. Eng. or Artificial Intelligence

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Goka, E., Beaurepaire, P., Homri, L., Dantan, J.-Y., 2019, Probabilistic-based approach using Kernel Density Estimation for gap modeling in a statistical tolerance analysis, Mechanism and Machine Theory, 139, pp. 294-309.
2. Goka, E., Homri, L., Beaurepaire, P., Dantan, J.-Y., 2019, Statistical tolerance analysis of over-constrained mechanical assemblies with form defects considering contact types, Journal of Computing and Information Science in Engineering, 19 (2), art. no. 021010-1.
3. Morse, E., Dantan, J.-Y., Anwer, N., Söderberg, R., Moroni, G., Qureshi, A., Jiang, X., Mathieu, L., 2018, Tolerancing: Managing uncertainty from conceptual design to final product, CIRP Annals, 67 (2), pp. 695-717.
4. Dantan, J.-Y., 2015, Comparison of Skin Model Representations and Tooth Contact Analysis Techniques for Gear Tolerance Analysis, Journal of Computing and Information Science in Engineering, 15 (2), art. no. 021010.
5. Dumas, A., Gayton, N., Dantan, J.-Y., Sudret, B., 2015, A new system formulation for the tolerance analysis of overconstrained mechanisms, Probabilistic Engineering Mechanics, 40, pp. 66-74.

Illustrations :

TITLE:CONTRIBUTION TO THE INTEGRATION OF ADDITIVE MANUFACTURING AND AUGMENTED REALITY IN EARLY DESIGN PHASES TO FOSTER CREATIVITY

Topic number : ***2021_014***

Field : Design, Industrialization, Information and Communication Science and Technology

Subfield: Additive Manufacturing, Augmented Reality, Design Methodology, Creativity, Computer Graphics.

ParisTech School: Arts et Métiers
Research team:
Research lab: LCPI - Laboratoire conception de produits et innovation
Lab location: Paris
Lab website:http://lcpi.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Segonds Frédéric frederic.segonds@ensam.eu
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Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: In the product design process, early stages are crucial as 80% of the design costs are engaged during these phases. Creativity is among one of the most important early activity as it allows to create breakthrough innovative products. Ideas are usually produced from inspirational sources such as images, 3D representations etc. These ideas are then retranscribed in ideas sheets to allow to select one (or more) concept to develop and industrialize.
As part of Industry 4.0, the idea generation phase can be enriched by the manipulation of physical objects made in Additive Manufacturing (AM). These objects can be produced on the fly to faithfully represent a concept to develop. In order to make this manipulation even more realistic, Augmented Reality (AR) technologies make it possible to apply a color and texture to a low-fidelity model. It allows users to see different appearances of a physical prototypes through the AR device and, at the same time, users can touch physically the object. Furthermore, with AR users can even change the shape and do some intuitive shape design activities. AR usually allows people to interact with virtual 3D mock-up integrated in the real world. The coupling of the two technologies (AM&AR) will thus favor the innovation of the design teams.

The aim of this PhD is to device and experiment AM&AR applications in the product design creativity activities in order answer the following research question : can experiencing AM&AR technologies foster creativity and innovation?

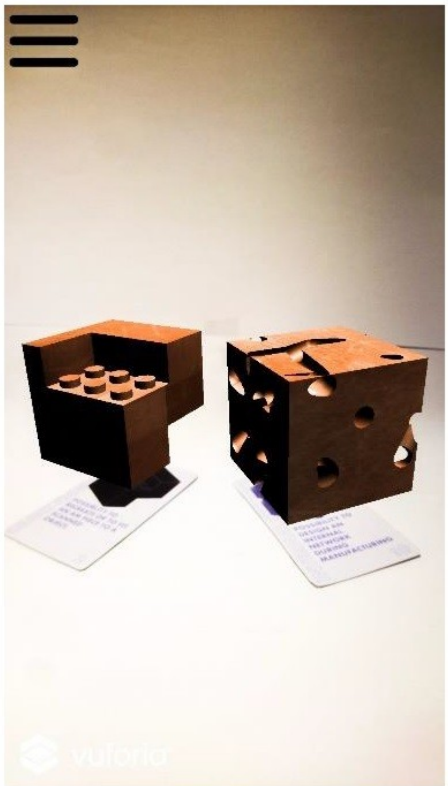
Required background of the student: Product design, creativity, innovation, additive manufacturing.
Computer science, computer graphics, geometric modeling, computer-aided design.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Rias, A. L., Segonds, F., Bouchard, C., & Abed, S. (2017). Towards additive manufacturing of intermediate objects (AMIO) for concepts generation. IJIDeM, 11(2), 301-315.
2. B. Li, F. Segonds, C. Mateev, R. Lou, F. Merienne (2018), Design in context of use: An experiment with a multi-view and multi-representation system for collaborative design, Computers in Industry, 103, pp. 28-37.
3. B. Faliu, A. Siarheyeva, R. Lou, F. Merienne (2019), Design and Prototyping of an Interactive Virtual Environment to Foster Citizen Participation and Creativity in Urban Design", LNISO (34), pp. 55 – 78.
4.
5.

Illustrations :


POSSIBILITY TO
BUILD ALMOST
ANY SHAPE
vuforia


POSSIBILITY TO
DESIGN AN
INTERNAL
NETWORK
DURING
MANUFACTURING

TITLE:DEVELOPMENT OF GUIDELINES TOOL TO PREVENT THE OCCURRENCE OF PLASTIC BUCKLING IN THIN STRUCTURES

Topic number : ***2021_015***

Field : Material science, Mechanics and Fluids

Subfield: Mechanical Engineering, Computational Mechanics

ParisTech School: Arts et Métiers
Research team:Méthodes Numériques, Instabilités et Vibrations (Numerical Methods, Instabilities and Vibrations)
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.univ-lorraine.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: ABED-MERAIM Farid Farid.Abed-Meraim@ensam.eu
Advisor 2: BEN BETTAIEB Mohamed Mohamed.BenBettaieb@ensam.eu
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Advisor 4:

Short description of possible research topics for a PhD: Plastic buckling is one of the most common structural instability phenomena that a thin structure may undergo during plastic loading. This phenomenon involves a sudden loss in strength for a structure due to the resulting post-buckling shape. Hence, to ensure structural integrity of thin structures, it is vital to carefully study this phenomenon and to develop the appropriate numerical tools and techniques capable of accurately preventing its occurrence. Despite the significant progress achieved in this area, the existing numerical tools and software packages suffer from several limitations and shortcomings, such as the poor description of the mechanical behavior of the studied structures. The current project aims to overcome these limitations by developing several reliable numerical tools and techniques in standalone codes or within the Abaqus Finite Element (FE) software. In these tools, advanced constitutive models, allowing for an accurate description of the mechanical behavior (based on macroscopic approaches or micro-macro frameworks involving relevant multiscale schemes), will be implemented and assessed. For validation purposes, the results obtained by the developed tools will be compared to benchmarks available in the literature as well as to some theoretical and experimental results. Once fully developed and validated, these tools will be used as design guidelines by the industry of thin structures.

Required background of the student: - Solid background in non-linear solid mechanics and numerical methods;
- Good analytical and programming skills (e.g., Matlab, Mathematica, C/C++, Fortran);
- Experience with Finite Element modeling would be an asset.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. M. Ben Bettaieb, F. Abed-Meraim (2015), “Investigation of localized necking in substrate-supported metal layers: Comparison of bifurcation and imperfection analyses”, International Journal of Plasticity, Vol. 65, pp. 168–190.
2. H.K. Akpama, M. Ben Bettaieb, F. Abed-Meraim (2017), “Localized necking predictions based on rate-independent self-consistent polycrystal plasticity: Bifurcation analysis versus imperfection approach”, International Journal of Plasticity, Vol. 91, pp. 205–237.
3. M.Y. Jedidi, M. Ben Bettaieb, F. Abed-Meraim, A. Bouguecha, M.T. Khabou, M. Haddar (2020), “Prediction of necking in HCP sheet metals using a two-surface plasticity model”, International Journal of Plasticity, Vol. 128, 102641.
4. J.C. Zhu, M. Ben Bettaieb, F. Abed-Meraim (2020), “Numerical investigation of necking in perforated sheets using the periodic homogenization approach”, International Journal of Mechanical Sciences, Vol. 166, 105209.
5. J.C. Zhu, M. Ben Bettaieb, F. Abed-Meraim (2020), “Investigation of the competition between void coalescence and macroscopic strain localization using the periodic homogenization multiscale scheme”, Journal of the Mechanics and Physics of Solids, Vol. 143, 104042.

Illustrations :

illustration CSC_2021_Illustrations_1

TITLE:DEVELOPMENT OF AN ADVANCED CPFEM TOOL FOR THE PREDICTION OF FORMABILITY LIMITS OF POLYCRYSTALLINE THIN METAL SHEETS

Topic number : ***2021_016***

Field : Material science, Mechanics and Fluids

Subfield: Mechanical Engineering, Computational Mechanics

ParisTech School: Arts et Métiers
Research team:Méthodes Numériques, Instabilités et Vibrations (Numerical Methods, Instabilities and Vibrations)
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.univ-lorraine.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: ABED-MERAIM Farid Farid.Abed-Meraim@ensam.eu
Advisor 2: BEN BETTAIEB Mohamed Mohamed.BenBettaieb@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: In contrast to macroscopic constitutive models, multiscale approaches allow naturally and explicitly linking physical microstructural parameters to some relevant in-use macroscopic properties. Consequently, multiscale constitutive approaches are nowadays widely used to predict the formability limits of thin metal sheets. Crystal plasticity finite element method (CPFEM) is considered to be one of the most reliable multiscale schemes for the accurate description of the mechanical behavior of polycrystalline aggregates exhibiting complex microstructures and/or mechanical behavior. In recent research projects, we have developed a robust and effective CPFEM tool to predict the mechanical behavior of heterogeneous materials and their formability limits. The first objective of the present project is to extend this tool to be able to capture more complex physical phenomena not considered in the former version (such as second-order effects due to grain size…). The second objective is to improve the description of the mechanical behavior at the microscale by considering physical mechanisms and phenomena not sufficiently investigated so far (such as an adequate description of dislocation density evolution, phase transformation present in TRIP and TWIP steels…). Once fully developed and validated, the resulting enhanced version of the CPFEM tool will be used, in academic and industrial contexts, to provide guidelines and assistance in the design of new generations of metallic alloys with improved ductility and in-use properties.

Required background of the student: - Solid background in non-linear solid mechanics and numerical methods;
- Good analytical and programming skills (e.g., Matlab, Mathematica, C/C++, Fortran);
- Experience with Finite Element modeling would be an asset.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. M. Ben Bettaieb, F. Abed-Meraim (2015), “Investigation of localized necking in substrate-supported metal layers: Comparison of bifurcation and imperfection analyses”, International Journal of Plasticity, Vol. 65, pp. 168–190.
2. H.K. Akpama, M. Ben Bettaieb, F. Abed-Meraim (2017), “Localized necking predictions based on rate-independent self-consistent polycrystal plasticity: Bifurcation analysis versus imperfection approach”, International Journal of Plasticity, Vol. 91, pp. 205–237.
3. M.Y. Jedidi, M. Ben Bettaieb, F. Abed-Meraim, A. Bouguecha, M.T. Khabou, M. Haddar (2020), “Prediction of necking in HCP sheet metals using a two-surface plasticity model”, International Journal of Plasticity, Vol. 128, 102641.
4. J. Paux, M. Ben Bettaieb, F. Abed-Meraim, H. Badreddine, C. Labergere, K. Saanouni (2020), “An elasto-plastic self-consistent model for damaged polycrystalline materials: Theoretical formulation and numerical implementation”, Computer Methods in Applied Mechanics and Engineering, Vol. 368, 113138.
5. J.C. Zhu, M. Ben Bettaieb, F. Abed-Meraim (2020), “Investigation of the competition between void coalescence and macroscopic strain localization using the periodic homogenization multiscale scheme”, Journal of the Mechanics and Physics of Solids, Vol. 143, 104042.

Illustrations :

illustration CSC_2021_Illustrations_2

TITLE:DEVELOPMENT OF AN ADVANCED NUMERICAL TOOL TO PREDICT THE BENDABILITY LIMITS DURING SHEET METAL FORMING PROCESSES

Topic number* : *2021_017

Field : Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:Méthodes Numériques, Instabilités et Vibrations (Numerical Methods, Instabilities and Vibrations)
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.univ-lorraine.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: ABED-MERAIM Farid Farid.Abed-Meraim@ensam.eu
Advisor 2: BEN BETTAIEB Mohamed Mohamed.BenBettaieb@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The vast majority of theoretical and numerical criteria developed to predict the occurrence of diffuse and/or localized necking are based on the simplifying modeling assumption that the studied metal sheets remain plane during forming processes. Hence, this conventional and widely-used assumption does not take into consideration the effect of sheet bending, and seems to be inadequate for analyzing the draw-type operations where sheet metal bends, slides and unbends over a draw radius. The main objective of the current PhD project is to extend the set of numerical tools, that we have developed within our research team for the prediction of diffuse necking (maximum force criterion, general bifurcation theory…) and localized necking (bifurcation theory, initial imperfection approach, …), in order to include the bending effects. The effect of the heterogeneity of the strain through the sheet thickness on the onset of necking will be especially investigated. The mechanical behavior of the bent sheets will be also carefully analyzed by implementing advanced and elaborate constitutive models (phenomenological and multiscale constitutive models) in our numerical tools. Finite element simulations will be performed to assess the accuracy of the developed tools. Once fully developed and validated, these advanced numerical tools will be used to improve the prediction of the bendability in several industrial and academic applications.

Required background of the student: - Solid background in non-linear solid mechanics and numerical methods;
- Good analytical and programming skills (e.g., Matlab, Mathematica, C/C++, Fortran);
- Experience with Finite Element modeling would be an asset.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. M. Ben Bettaieb, F. Abed-Meraim (2015), "Investigation of localized necking in substrate-supported metal layers: Comparison of bifurcation and imperfection analyses", International Journal of Plasticity, Vol. 65, pp. 168–190.
2. M. Ben Bettaieb, F. Abed-Meraim, X. Lemoine (2019), "Numerical investigation of the combined effects of curvature and normal stress on sheet metal formability", International Journal of Material Forming, Vol. 12, Issue 2, pp. 211–221.
3. M.Y. Jedidi, M. Ben Bettaieb, F. Abed-Meraim, A. Bouguecha, M.T. Khabou, M. Haddar (2020), "Prediction of necking in HCP sheet metals using a two-surface plasticity model", International Journal of Plasticity, Vol. 128, 102641.
4. J. Paux, M. Ben Bettaieb, F. Abed-Meraim, H. Badreddine, C. Labergere, K. Saanouni (2020), "An elasto-plastic self-consistent model for damaged polycrystalline materials: Theoretical formulation and numerical implementation", Computer Methods in Applied Mechanics and Engineering, Vol. 368, 113138.
5. J.C. Zhu, M. Ben Bettaieb, F. Abed-Meraim (2020), "Investigation of the competition between void coalescence and macroscopic strain localization using the periodic homogenization multiscale scheme", Journal of the Mechanics and Physics of Solids, Vol. 143, 104042.

Illustrations :

illustration CSC_2021_Illustrations_3

TITLE:IMPROVEMENT OF SURFACE PROPERTIES BY PVD-THERMOCHEMISTRY HYBRID TREATMENT ON METAL SUBSTRATES OBTAINED BY CONVENTIONAL MANUFACTURING PROCESSES AND BY POWDER METALLURGY

Topic number : ***2021_018***

Field : Material science, Mechanics and Fluids

Subfield: Material science and engineering, Surface treatment, PVD coatings, thermochemical treatment, powder metallurgy, diffusion

ParisTech School: Arts et Métiers
Research team:MSE Materials and Surfaces Engineering
http://labomap.ensam.eu/materials-and-surfaces-engineering-100828.kjsp?RH=1415278881726&RF=1415870833775
Research lab: LABOMAP - Laboratoire Bourguignon des matériaux et procédés
Lab location: Cluny
Lab website:labomap.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: Nouveau Corinne corinne.nouveau@ensam.eu
Advisor 2: Cotton Dominique dominique.cotton@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The LaBoMaP has a recognized expertise in vacuum treatment products, which are commonly used in numerous domains (transport, health, energy, etc.). The purpose is to improve the surface properties of the devices, in particular to protect them from severe solicitations (corrosion, abrasion, etc.). Both processes studied in the laboratory are Physical Vapor Deposition (PVD) and thermochemical treatments under vacuum, as well as their combination or "hybrid treatments". The aim is to thermochemically treat PVD metallic coatings (such as Cr, Ti..) to convert them in binary compounds (CrN, TiC etc). The objective of this PhD will be to master the numerous parameters that can influence both processes, to obtain the hard surface layer and the adequate gradient of hardness for its mechanical strength. First, substrates obtained by conventional manufacturing processes (forging, rolling) will be used. Then, the same substrates will be elaborated by metal powders in ICB laboratory

(University of Burgundy, Dijon), having a reputed expertise in this field, by Spark Plasma Sintering (SPS) and the Hot Isostatic Pressing (HIP). The project will be organized in 5 axes according to figure 1.

Required background of the student: 1. A master’s degree in materials science (knowledge in metallurgy, surface treatments, diffusion, characterizations techniques such as SEM, XRD, EBSD etc).
2. Ability to work independently, to plan and carry out tasks, and to be a part of a large, dynamical group.
3. Good communication skills in English and/or French, both written and spoken.
4. Experience with powder metallurgy is an advantage but not an exclusion criterion

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Influence of Substrate Bias Voltage on Corrosion and Wear Behavior of Physical Vapor Deposition CrN Coatings, Aouadi, K., Tlili, B., Nouveau, C., ...Chafra, M., Souli, R., Journal of Materials Engineering and Performance, 2019, 28(5), pp. 2881-2891
2. Low-temperature plasma nitriding of martensitic stainless steel, Rao, K.R.M., Nouveau, C., Trinadh, K., Transactions of the Indian Institute of Metals, 2020, 73(6), pp. 1695-1699
3. Thermal treatment effect on structural and mechanical properties of Cr–C coatings, Fellah, M., Aissani, L., Zairi, A., ...Montagne, A., Iost, A., Transactions of the Institute of Metal Finishing, 2018, 96(2), pp. 79-85
4. A study of the tribological behavior of duplex treatment, Siad A., Nouveau C., Besnard A., Jacquet P, Annales de Chimie - Science Des Matériaux, 2015, 39(3-4), pp. 201-208
5. Influence of the process parameters on the microstructure of a hardfacing coating elaborated by hot isostatic pressing, Tellier, A., Ardigo-Besnard, M.R., Chateau-Cornu, J.-P., Archives of Metallurgy and Materials, 2019, 64(1), pp. 33-38

Illustrations :

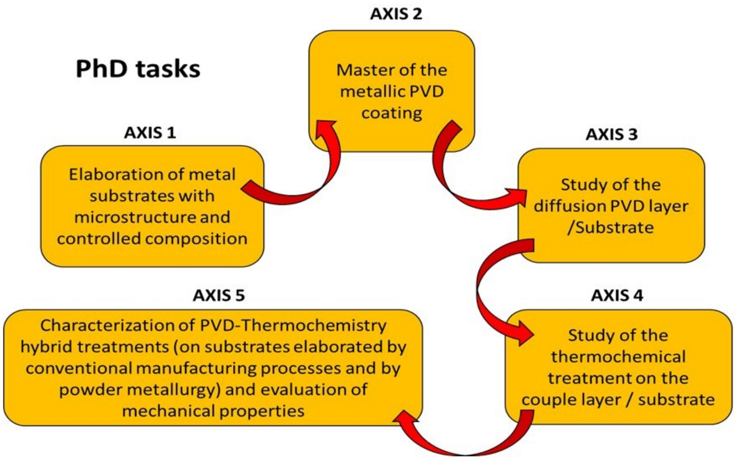


Figure 1. PhD tasks

TITLE:MEASUREMENT OF RESIDUAL STRESSES IN MATERIALS: FEM-BASED SIMULATION OF X-RAY DIFFRACTION

Topic number : ***2021_019***

Field : Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:MMS
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location: Aix-en-Provence
Lab website:https://www.msmp.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Depriester Dorian dorian.depriester@ensam.eu
Advisor 2: barrallier laurent laurent.barrallier@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: It is well known that, in many cases, residual stresses can improve lifespan of mechanical parts. In order to estimate those stresses, one of the most widely used techniques is based on X-ray diffraction (XRD). In crystalline materials, such as metals or ceramics, this techniques consists in measuring the reticular distances (distance between atomic plane of the crystals) thanks to the Bragg's law, thus providing information about the strain applied on the grains. Since the strain due to residual stresses is necessarily elastic, the residual stresses can be inferred from the reticular distances.

The aim of this project is to develop an innovative direct way to correlate XRD measurements with residual stresses. It will consists in simulating the XRD experiment on a strained polycrystal, generated with the aid of numerical tools dedicated to synthetic aggregate generation (e.g. NEPER software). Thanks to the results from Finite Element Analysis (FEA) performed at grain scale on polycrystalline aggregates, the local strain within each grain will be used to simulate the XRD experiment through implementation of the Bragg's law and ray-tracing techniques. Thus, the objective is to simulate the XRD experiment, taking into account the local heterogeneities (phases, crystalline orientations...). This approach will also model the artefacts inherent to XRD (polychromatism, divergence of the X-ray beam etc.).

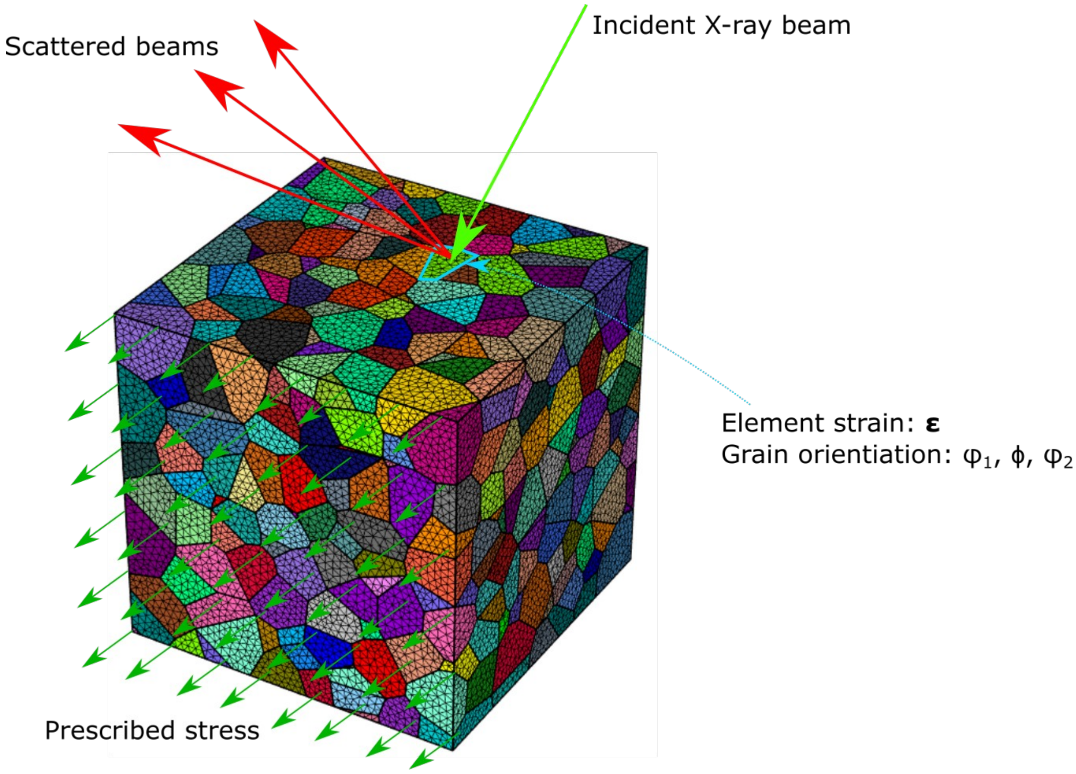
XRD experiments will be performed in order to assess the model. When the model is checked, numerical simulations will be performed in various conditions (in terms of microstructures, experimental conditions and residual stress distributions) so that sensitivity analysis will be performed. In terms, an Articial Intelligence (AI) algorithm will be trained from these datasets, allowing to provide a new tool for analyzing XRD diagrams.

Required background of the student: Continuum mechanics, crystallography, Finite Element Methods, python programing

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Depriester D., Kubler R. (2019). Radical Voronoï tessellation from random pack of polydisperse spheres: Prediction of the cells' size distribution, Computer-Aided Design, Volume 107, 37-49, https://doi.org/10.1016/j.cad.2018.09.001
2. Depriester, D., Kubler, R. (2019). Resolution of the Wicksell's equation by Minimum Distance Estimation. Image Analysis & Stereology, Volume 38(3), 213–226
https://doi.org/10.5566/ias.2133
3. Depriester D., Kubler R. (2021). Grain size estimation in polycrystals: Solving the corpuscle problem using Maximum Likelihood Estimation, Journal of Structural Geology, Volume 151
https://doi.org/10.1016/j.jsg.2021.104418.
4.
5.

Illustrations :



Scattered beams
Incident X-ray beam
Element strain: ε
Grain orientation: φ1, ϕ, φ2
Prescribed stress

TITLE:SURFACE INTEGRITY OF TI-6AL-4V ALLOY COMPONENTS PRODUCED BY SLM AND MACHINING PROCESSES: MULTIPHYSICS SIMULATIONS AND EXPERIMENTAL VALIDATION

Topic number : ***2021_021***

Field : Material science, Mechanics and Fluids

Subfield: Mechanical Engineering, Manufacturing processes, Additive Manufacturing, Machining

ParisTech School: Arts et Métiers
Research team:High Speed Machining
Research lab: LABOMAP - Laboratoire Bourguignon des matériaux et procédés
Lab location: Cluny
Lab website:http://labomap.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: OUTEIRO Jose jose.outeiro@ensam.eu
Advisor 2: Moufki Abdelhadi abdelhadi.moufki@univ-lorraine.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Selective Laser Melting (SLM) is an additive manufacturing (AM) process used to produce functional prototypes and small series of Titanium alloys components with high mechanical properties and high geometrical complexity. Additionally, to obtain a functional product with geometrical/dimensional and surface integrity requirements, the components produced by SLM need to be finished using a machining process. The rapid cooling of the material during SLM leads to thermally induced residual stresses distributions in the components. These stresses can affect the machining process, causing part distortion and poor surface integrity. This will affect the functional performance and life of the titanium components, such as fatigue life and corrosion resistance. In this work, the physical phenomena and the surface integrity of Ti-6Al-4V alloy generated by both SLM and machining processes will be investigated using Multiphysics Simulations, carefully validated by experimental tests. The aim of Multiphysics Simulations is to determine the SLM and machining processes conditions that will enhance the surface integrity of SLM-produced components.

Required background of the student: We are looking for a highly motivated candidate with a Master's degree in Mechanical Engineering or Materials Science. A knowledge of the finite element method and continuum mechanics will be considered a strong merit. Other desirable experience but not essential includes the MATLAB programming language.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. K.S.Djaka, A.Moufki, M.Nouari, P.Laheurte, A.Tidu. A semi-analytical modelling of cutting using crystal plasticity theory and flow line approach. Int. J. of Mechanical Sciences, 146-147, 49-59, 2018.
2. A. Moufki, D. Dudzinski, G. Le Coz, Prediction of cutting forces from an analytical model of oblique cutting, application to peripheral milling of Ti-6Al-4V alloy, International Journal of Advanced Manufacturing Technology, 81 (1-4), 615-626, 2015.
3. X. Xu, Jun Zhang, J.C. Outeiro, B. Xu, W. Zhao. Multiscale simulation of grain refinement induced by dynamic recrystallization of Ti6Al4V alloy during high speed machining. Journal of Materials Processing Technology, 286, 116834, 2020.
4. F. Careri, S. Imbrogno, D. Umbrello, M. M. Attallah, J.C. Outeiro, A. C. Batista, Machining and Heat Treatment as Post-Processing Strategies for Ni-Superalloys Structures Fabricated using Direct Energy Deposition, Journal of Manufacturing Processes, Vol. 61, pp. 236-244, 2021
5. I.S. Jawahir, E. Brinksmeier, R. M'Saoubi, D.K. Aspinwall, J.C. Outeiro, D. Meyer, D. Umbrello, A.D. Jayal. Surface Integrity in Material Removal Processes: Recent Advances. CIRP Annals - Manufacturing Technology, keynote paper, 60 (2), 603-626, 2011.

Illustrations :

TITLE:SIMULTANEOUS OPTIMIZATION OF ANISOTROPY AND TOPOLOGY OF COMPOSITES FROM ADDITIVE MANUFACTURING PROCESS BY CONSIDERING STRENGTH CRITERIA BASED ON INVARIANTS

Topic number : ***2021_026***

Field : Design, Industrialization, Material science, Mechanics and Fluids, Mathematics and their applications

Subfield: Mechanics of materials and structures, additive manufacturing, topology optimisation, material optimisation, multi-scale analysis

ParisTech School: Arts et Métiers
Research team:IMC departement
https://www.i2m.u-bordeaux.fr/Recherche/IMC-Ingenierie-Mecanique-et-Conception
Research lab: I2M - Institut de Mécanique et d'ingénierie
Lab location: Bordeaux
Lab website:https://www.i2m.u-bordeaux.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: Montemurro Marco marco.montemurro@ensam.eu
Advisor 2: Catapano Anita anita.catapano@bordeaux-inp.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The development of a general multi-scale modelling strategy coupled with a general optimization methodology and a dedicated mathematical formalism to represent both the topology and the anisotropy of the continuum (at each scale) is of paramount importance to carry out the concurrent optimization of the topology and of the fibres-path for variable stiffness composites (VSCs) fabricated through the Fused Filament Fabrication (FFF) + Continuous Filament Fabrication (CFF) technology. Moreover, the design strategy must take into account the specificities of the FFF+CFF process since the preliminary design phase to get optimized and manufacturable products.
The heterogeneity at the microscale (the scale of the constituents) and the anisotropy involved at the mesoscale (the scale of the ply) as well as at the macroscale (the scale of the structure), represent the main difficulties in the design process of these structures.
The following three main challenges will be addressed in this Thesis:

1. The simultaneous optimization of the anisotropy and the topology descriptors at the macroscopic scale through a suitable mathematical description of the anisotropy based on invariants related to the elastic symmetries
2. The formulation of the manufacturing constraints involved at the mesoscopic scale (i.e. fibres-path within each lamina) as equivalent constraints on the elastic invariants at the macroscopic scale. Typical manufacturing constraints are on the minimum steering radius, resin-rich areas, fiber tape width, etc.
3. The development of suitable criteria to take into account local damage mechanisms to be translated into equivalent mechanical constraints on the elastic invariants at the macroscopic scale.

Required background of the student: Theoretical and applied mechanics, applied mathematics, programming skills, good knowledge of the finite element method

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. M. Montemurro, A. Catapano. A general B-Spline surfaces theoretical framework for optimisation of variable angle-tow laminates. Composite Structures 209: 561-578, 2019. URL: https://doi.org/10.1016/j.compstruct.2018.10.094
2. G. A. Fiordilino, M. I. Izzi, M. Montemurro. A general isogeometric polar approach for the optimisation of variable stiffness composites : application to eigenvalue buckling problems. Mechanics of Materials 153: 103574, 2021. URL : https://doi.org/10.1016/j.mechmat.2020.103574
3. M. I. Izzi, A. Catapano, M. Montemurro. Strength and mass optimisation of variable-stiffness composites in the polar parameters space. Structural and Multidisciplinary Optimization volume 64: 2045–2073, 2021. URL: https://doi.org/10.1007/s00158-021-02963-7
4. 4. G. Costa, M. Montemurro, J. Pailhès. A 2D topology optimisation algorithm in NURBS framework with geometric constraints. International Journal of Mechanics and Materials in Design, v. 14 (4), pp. 669-696, 2018. URL: https://doi.org/10.1007/s10999-017-9396-z
5. T. Roiné, M. Montemurro, J. Pailhès. Stress-Based Topology Optimisation through Non-Uniform Rational Basis Spline Hyper-Surfaces.

Mechanics of Advanced Materials and Structures, URL:
https://doi.org/10.1080/15376494.2021.1896822, 2021 (in press).

Illustrations :

illustration Slide_topic_Montemurro_Catapano

TITLE:THE MECHANICS OF EARTHQUAKES AND FAULTING: INFLUENCE OF FRICTION PROPERTIES AND FAULT MATERIAL ON RUPTURE TIP PROPAGATION

Topic number : ***2021_032***

Field : Environment Science and Technology, Sustainable Development, Geosciences, Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location: Angers
Lab website:lampa.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: AMMAR Amine amine.ammar@ensam.eu
Advisor 2: EL AREM Saber saber.elarem@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: In the last two decades, considerable observational and theoretical work has been devoted to all aspects of earthquake prediction research, for solving

fundamental questions concerning the mechanics of fault systems, as well as for
answering questions regarding earthquake hazard. The european natural

observatory of the Corinth Rift (http://crlab.eu), a very rapidly deforming area
(opening strain rate of ~10 -6 /yr) where one or more earthquakes with

magnitudes above 6 are expected in the coming decades provides a framework
in which the mechanics of faults can be studied in details. It is densely

instrumented and provides an exceptional data base (seismological, GPS and strain data). All the prediction approaches in the literature rely on some

probabilistic description of earthquake generation and timing, through empirical
laws guided, or structured, by some simplification of the underlying physical
process. This requires that relevant physical models and observational

constraints are put at the core of any probabilistic law seismic-hazard

assessment. Based on advanced numerical modeling, our objective is to examine the fault zones
material behavior and its relation to earthquake dynamics, the description friction at slow rates (interseismic period)
and earthquake nucleation, and the dynamics of fault weakening during rapid slip. Numerical results will be compared to
in laboratory experiments and to field observation.

Required background of the student:

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Christopher Scholz, The Mechanics of Earthquakes and Faulting, Cambridge University Press, 2019

2. James R. Rice, Nadia Lapusta, K. Ranjith,Rate and state dependent friction and the stability of sliding between elastically deformable solids,Journal of the Mechanics and Physics of Solids, September 2001

3. P. Bernarda, H. Lyon-Caen et al., Tectonophysics, Volume 426, Issues 1–2, 30
October 2006, Pages 7–30

4. S. El Arem, H. Lyon-Caen, P. Bernard, J-D Garaud, F. Rolandone, and P.

Briole. In EGU General Assembly Conference , volume 15, page 14477,Vienna, Austria, 2013

5.

Illustrations :

illustration FigureFault

illustration_2 CSCFaults

illustration_3 Disp_U1

TITLE:MULTISCALE STRESS/STRAIN ANALYSIS OF POLYCRYSTALLINE SILICON FOR PHOTOVOLTAIC APPLICATIONS

Topic number : ***2021_034***

Field : Material science, Mechanics and Fluids

Subfield: Photovotaic

ParisTech School: Arts et Métiers
Research team:MMS https://www.msmp.eu/equipes/mms/
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location: Aix-en-Provence
Lab website:msmp.eu

Contact point for this topic: Arts et Métiers

Advisor 1: barrallier laurent laurent.barrallier@ensam.eu
Advisor 2:
Advisor 3:
Advisor 4:

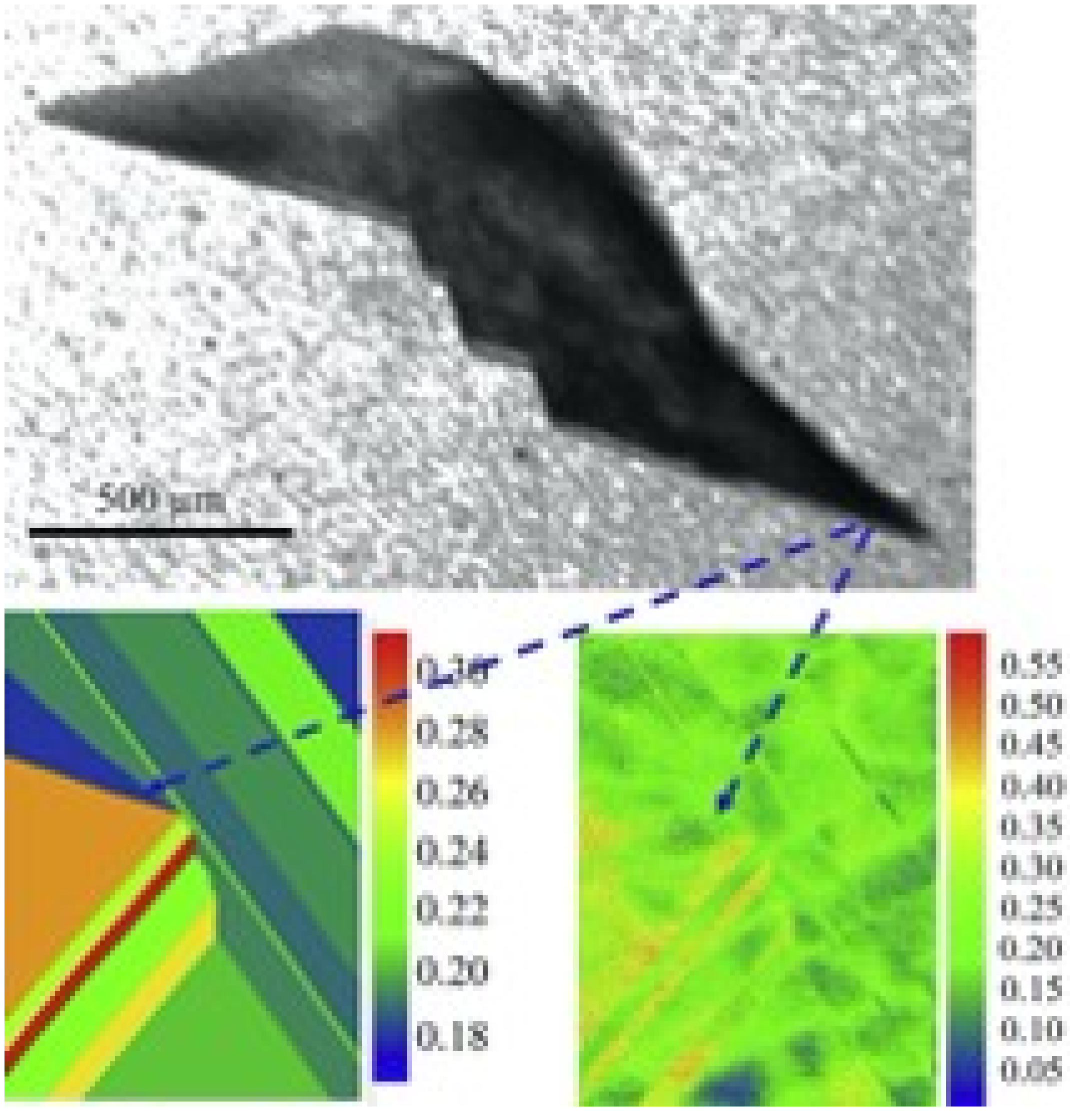
Short description of possible research topics for a PhD:
Polycrystalline silicon (PS) is a raw material used by the solar photovoltaic (PV) and electronics industry. The reduction of the cost of PV cells production is largely possible by using PS. Nevertheless, the limitation of PS use is directly linked to the microstructure of the material i.e. i) the active defects such as grain boundaries, dislocation arrangements, … ii) but also the mechanical fields induced by these defects. The efficiency of PV cells is depending on the mastering of the defect generation, their repartition and the induced strain/stress fields during the fabrication of PS.
The aim of this project is to characterize the induced residual stress fields of PS in relation with their microstructure. Experimental methods used to determine residual stresses fields will be based on multiscale diffraction in-lab technics such as High-Resolution Electron Backscatter Diffraction (HR-EBSD), X-ray diffraction (XRD) of synchrotron facility. To understand the origin of residual stress fields in PS cells, the temperature HR-EBSD and XRD measurements will be coupled with polycrystalline thermo-elasto-plasticity simulation using finite element method (FEM).

Required background of the student: Materials Science and/or Mechanical Engineering

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. M. Becker, E. Pihan, F. Guittonneau, L. Barrallier, G. Regula, H. Ouaddah, G. Reinhart, and N. Mangelinck-Noël. Investigation of subgrains in directionally solidified cast mono-seeded silicon and their interactions with twin boundaries. Solar Energy Materials & Solar Cells, 218(110817):1-10, décember 2020.
2. N. Mangelinck-Noel, H. Ouaddah, M. Becker, T. Riberri-Beridot, M. Tsoutsouva, V. Stamelou, G. Regula, G. Reinhart, I. Péricaud, F. Guittonneau, L. Barrallier, J.-P. Valade, A. Rack, E. Boller, and J. Baruchel. X-ray based in situ investigation of silicon growth mechanism dynamics-application to grain and defect formation. Crystals, 10(7):1-25, july 2020.
3. T. Riberi-Béridot, M.G. Tsoutsouva, G. Regula, G. Reinhart, F. Guittonneau, L. Barrallier, and N. Mangelinck-Noël. Strain building and correlation with grain nucleation during silicon growth. Acta Materiala, 177:141-150, 09 2019.
4. M.G Tsoutsouva, T. Riberi-Béridot, G. Regula, G. Reinhart, J. Baruchel, F. Guittonneau, L. Barrallier, and N. Mangelinck-Noël. In situ investigation of the structural defect generation and evolution during the directional solidification of 110 seeded growth si. Acta Materiala, 115:210-223, August 2016.
5. T. Riberri-Beridot, N. Mangelinck-Noel, A. Tandjouai, G. Reinhart, B. Billia, B. Lafford, J. Baruchel, and L. Barrallier. On the impact of twinning on the formation of the grain structure of multi-crystalline silicon for photovoltaic applications during directional solidification. Journal of Crystal Growth, (418):38-44, 2015.

Illustrations :



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TITLE:LEARNING WITH IMMERSIVE TECHNOLOGIES

Topic number* : *2021_035

Field : Design, Industrialization, Information and Communication Science and Technology

Subfield: Virtual Reality

ParisTech School: Arts et Métiers
Research team:Presence & Innovation
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location:
Lab website:http://lampa.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: RICHIR SIMON simon.richir@ensam.eu
Advisor 2: Gorisse Geoffrey geoffrey.gorisse@ensam.eu
Advisor 3: Fleury Sylvain sylvain.fleury@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: The proposed research project aims at investigating the potential of immersive technologies (virtual reality, augmented reality) to learn technical and/or scientific contents. Virtual and augmented reality have developed rapidly over the last twenty years, both in terms of hardware and software quality, which offers several potentialities and use cases. However, these technologies remain under-exploited in several fields. The digital learning transformation, particularly in higher education and professional training, requires further investigations in order to adapt to the cognitive characteristics of learners and to develop pedagogical approaches that integrate these technologies in a relevant way.
Today, the main obstacles to the use of immersive technologies for learning are not only technical, but also ergonomics and pedagogical. It is necessary to identify the conditions of effectiveness of these devices by working on a better understanding of users' cognitive functioning in learning situations. More specifically, we want to study how virtual agents (autonomous characters controlled by the computer) can be used to facilitate learning. For instance, we could investigate how a virtual agent acting as a tutor could facilitate the learning of a technical procedure.

We could also study how to "capture" a teacher's lesson and how to reproduce it in a virtual environment, through a virtual agent (using the "CAPLAB" platform being installed in Laval).
In this context, experiments could be carried out to identify the optimal characteristics of this virtual tutor, in terms of realism, attractiveness and behavior, in order to enhance learners' motivation. Evaluations could focus on learning performance (memorization, understanding, ability to reproduce the task in realistic context), participant involvement, but also on learners' satisfaction in order to guarantee the acceptability of the technologies used in such contexts.
The use of artificial intelligence modules could be considered if this subject interests the selected candidate for the thesis.
This work will lead to high-level international publications that will shed light on relevant pedagogical tools and good practices for learning using immersive technologies.

Required background of the student: Master's degree in computer science with extended knowledge of virtual reality. We are looking for a candidate with an interest in multidisciplinary research, at the frontier of virtual reality and experimental psychology. A strong interest for experimental research is required: production of protocols, conducting experiments, data analysis and writing. Applicants are expected to read, speak and write academic english.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Buttussi, F., & Chittaro, L. (2017). Effects of different types of virtual reality display on presence and learning in a safety training scenario. IEEE transactions on visualization and computer graphics, 24(2), 1063-1076.
2. Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. Journal of Computers in Education, 8(1), 1-32.
3. Hew, K. F., & Cheung, W. S. (2010). Use of three-dimensional (3-D) immersive virtual worlds in K-12 and higher education settings: A review of the research. British journal of educational technology, 41(1), 33-55.
4. Makransky, G., Andreasen, N. K., Baceviciute, S., & Mayer, R. E. (2020). Immersive virtual reality increases liking but not learning with a science simulation and generative learning strategies promote learning in immersive virtual reality. Journal of Educational Psychology.

5. Parong, J., & Mayer, R. E. (2018). Learning science in immersive virtual reality. Journal of Educational Psychology, 110(6), 785.

Illustrations :

Title:Thermal and mechanical fatigue behavior of selective laser melting maraging steel (H11 or H13)

Topic number : ***2021_036***

Field : Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:I2MP Multiphysical and multiscale approach to manufacturing processes
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location: Châlons-en-Champagne
Lab website:https://www.msmp.eu

Contact point for this topic: Arts et Métiers

Advisor 1: KANG Nan nan.kang@ensam.eu
Advisor 2: EL MANSORI Mohamed mohamed.elmansori@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Due to the high strength, high hardness and wear resistance, Maraging steel has been considered as one of popular candidates for die manufacturing. Recently, selective laser melting (SLM) process has been widely used to prepare the complex die with desirable conforming cooling system. However, the uniform equilibrium solidification condition induced heterogenous microstructure makes the SLM processed component presenting intrinsic different mechanical performance, especially, the dynamic fatigue behavior. In this project, the thermal and mechanical fatigue behavior of SLM processed maraging steel will be investigated with focus on the defects and multi-scale structure. The crack behavior at different stage will be characterized using the X-ray CT instrument for obtaining an effective fatigue prediction method.

Required background of the student: 1. Candidates should have a master degree in materials science or mechanical engineering;
2. A background in additive manufacturing, laser materials processing will be a clear advantage;
3. The Fatigue behavior investigation experience on SLM processed

component is preferred;
4. Candidates should be able to work in a multidisciplinary environment and be fluent in English (both oral and written)

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. (1) P. Kumar, R. Jayaraj, J. Suryawanshi, U.R. Satwik, J. McKinnell, U. Ramamurty, Fatigue strength of additively manufactured 316L austenitic stainless steel, Acta Mater. 199 (2020) 225-239.
2. (2) R.Branco, J.D. Costa, J.A. Martins Ferreira, C. Capela, F.V. Antunes, W. Macek, Multiaxial fatigue behaviour of maraging steel produced by selective laser melting, Mater. Design 201 (2021) 109469.
3. (3) S. Afkhami, M. Dabiri, S. Habib Alavi, T. Björk, A. Salminen, Fatigue characteristics of steels manufactured by selective laser melting, International Journal of Fatigue, 122 (2019) 72-83.
4.
5.

Illustrations :

TITLE:MULTI-SCALED STRUCTURE DESIGN OF THERMAL CONTROLLABLE COMPLEX CONFORMING COOLING CHANNEL SYSTEM IN SELECTIVE LASER MELTING PROCESS

Topic number : ***2021_037***

Field : Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:I2MP Multiphysical and multiscale approach to manufacturing processes
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location: Châlons-en-Champagne
Lab website:https://www.msmp.eu

Contact point for this topic: Arts et Métiers

Advisor 1: EL MANSORI Mohamed mohamed.elmansori@ensam.eu
Advisor 2: KANG Nan nan.kang@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Selective laser melting (SLM), a laser assisted powder bed fusion technology, presents an outstanding forming ability in the component with extremely high complex morphology. Design for Additive Manufacturing (DfAM) is the art, science and skill to design for manufacturability using AM technology. Until now several works have been done in this field and realized the real component with focus on the 3D geometrical conception. But, the coupled thermal-stress filed during manufacturing procedure is materials-guided and dynamic, which should be considered for the extremely complex component, such as conforming cooling system. The objective of this work is the investigation of the effect of in-situ and ex-situ heat, stress and strain on structure-material design with emphasis on thermal-stress coupling simulation. The outcomes include design guidelines for geometric conception and experimentally realization to meet the SLM processed component.

Required background of the student: 1. Candidates should have a master degree in materials science or mechanical engineering;

2. A background in additive manufacturing, laser materials processing, and topology optimization and solidification will be a clear advantage;

3. The Computer Aided Design (CAD) and Finite Elemental Analysis (FEA) experience on the thermal-coupled simulation is preferred;
4. Candidates should be able to work in a multidisciplinary environment and be fluent in English (both oral and written)

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Cao Y., Lin X., Kang N., Ma L., Wei. L, Zheng M., Yu J., Peng D.J., Huang W.D., A novel high-efficient finite element analysis method of powder bed fusion additive manufacturing Addi Manuf 46 (2021) 102187
2. Kang N., Coddet P., Ammar M.R., Liao H.L., Coddet C. Characterization of the microstructure of a selective laser melting processed Al-50Si alloy: Effect of heat treatments, Mater. Character., 130 (2017) 243-249.
3. R.Magana-Carranza, C.J.Sutcliffe, E.A. Patterson, The effect of processing parameters and material properties on residual forces induced in Laser Powder Bed Fusion (L-PBF) Addi Manuf 46 (2021) 102192.
4.
5.

Illustrations :

Title:Mechanical and Functional fatigue behavior of selective laser melted NiTi Shape Memory Alloy

Topic number : ***2021_038***

Field : Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:I2MP Multiphysical and multiscale approach to manufacturing processes
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location: Châlons-en-Champagne
Lab website:https://www.msmp.eu

Contact point for this topic: Arts et Métiers

Advisor 1: EL MANSORI Mohamed mohamed.elmansori@ensam.eu
Advisor 2: El Hadrouz Mourad mourad.elhadrouz@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Shape memory alloys (SMAs) are one class of materials exhibiting functional properties, which can return to a predetermined shape when heated. To fully utilize these properties, NiTi needs to be processed into various geometries for different applications. However, conventional manufacturing methods have several limitations including the contamination of the crucible by oxygen. In addition, NiTi is a material that is difficult to process due to its compositional sensitivity and poor machinability. Recently, Selective Laser Melting (SLM) has been considered as one possible near net-shaped process to overcome these shortages. In this project, the mechanical and functional fatigue behavior of SLM processed NiTi will be investigated. The correlation analyses between fatigue life and the factors of surface roughness, porosity, and residual stress will be evaluated. The crack behavior at different stage will be characterized using the X-ray CT instrument for obtaining an effective fatigue prediction method. The synergistic effects of part densification, residual stress, and microstructure variable will be quantified to assess the fatigue performance.

Required background of the student: 1. Candidates should have a master degree in materials science or mechanical engineering;
2. A background in additive manufacturing, laser materials processing will be a clear advantage;
3. The Fatigue behavior investigation experience on SLM processed component is preferred;
4. Candidates should be able to work in a multidisciplinary environment and be fluent in English (both oral and written)

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Ayati, P., Safaei, K., Nematollahi, M., Jahadakbar, A., Yadollahi, A., Mahtabi, M., Elahinia, M. Toward understanding the effect of remelting on the additively manufactured NiTi (2021) International Journal of Advanced Manufacturing Technology, 112 (1-2), pp. 347-360.
2. Bayati, P., Jahadakbar, A., Barati, M., Nematollahi, M., Saint-Sulpice, L., Haghshenas, M., Chirani, S.A., Mahtabi, M.J., Elahinia, M. Toward low and high cycle fatigue behavior of SLM-fabricated NiTi: Considering the effect of build orientation and employing a self-heating approach (2020) International Journal of Mechanical Sciences, 185, art. no. 105878.
3. Speirs, M., Van Hooreweder, B., Van Humbeeck, J., Kruth, J.-P. Fatigue behaviour of NiTi shape memory alloy scaffolds produced by SLM, a unit cell design comparison (2017) Journal of the Mechanical Behavior of Biomedical Materials, 70, pp. 53-59
4.
5.

Illustrations :

TITLE:RISK MANAGEMENT OF ENGINEERING PRODUCTS DRIVEN BY ARTIFICIAL INTELLIGENCE

Topic number : ***2021_039***

Field : Design, Industrialization

Subfield: Industrial Engineering

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: SIADAT Ali ali.siadat@ensam.eu
Advisor 2: PETRONIJEVIC Jelena jelena.petronijevic@ensam.eu
Advisor 3: ETIENNE Alain alain.etienne@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: With the pace of technological development, the complexity of industrial products is increasing. As a result, its risk management is becoming demanding and data-driven risk models are needed. However, the adoption of these approaches is still slow as risk management is highly dependent on experts whose knowledge is often captured in textual and descriptive form (e.g. FMEA and risk register) including at the same time the source of risk, interaction and effect. Building the model based on this form requires understanding of human perception and communication.
The aim of this thesis is to bridge the gap between the conventional way in which risks are represented and the desired model-based risk management. More specifically, the research involves risk identification and analysis with the use of artificial intelligence conducted in two phases. Beginning with text-based risk knowledge, the objective is to apply deep learning techniques (e.g. natural language processing) to the identification of risk drivers. Based on this step, the risk model of the engineering product is to be developed. The thesis therefore leads towards automated risk management, which minimizes the costs and time required for this process.

Required background of the student:

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Azarian, A., Siadat, A., & Martin, P. (2011). A new strategy for automotive off-board diagnosis based on a meta-heuristic engine. Engineering Applications of Artificial Intelligence, 24(5), 733-747.
2. Mili, A., Bassetto, S., Siadat, A., & Tollenaere, M. (2009). Dynamic risk management unveil productivity improvements. Journal of Loss Prevention in the Process Industries, 22(1), 25-34.
3. Petronijevic, J., Etienne, A., Siadat, A., & Bassetto, S. (2019, September). Operational Framework for Managing Risk Interactions in Product Development Projects. In 2019 International Conference on Industrial Engineering and Systems Management (IESM) (pp. 1-6). IEEE.
4. Petronijevic, J., Etienne, A., & Dantan, J. Y. (2019). Human factors under uncertainty: A manufacturing systems design using simulation-optimisation approach. Computers & Industrial Engineering, 127, 665-676.
5. Shah, L. A., Etienne, A., Siadat, A., & Vernadat, F. (2016). Decision-making in the manufacturing environment using a value-risk graph. Journal of Intelligent Manufacturing, 27(3), 617-630.

Illustrations :

TITLE:OPTIMIZED SET-UP TO CHARACTERIZE THE CONTACT FATIGUE DAMAGE OF MATERIAL WITH GRADIENT PROPERTIES

Topic number : ***2021_040***

Field : Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:Mechanics, Materials and Surfaces
https://www.msmp.eu/equipes/mms/
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location: Aix-en-Provence
Lab website:https://www.msmp.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Goulmy Jean-Patrick jean-patrick.goulmy@ensam.eu
Advisor 2: barrallier laurent laurent.barrallier@ensam.eu
Advisor 3:
Advisor 4:

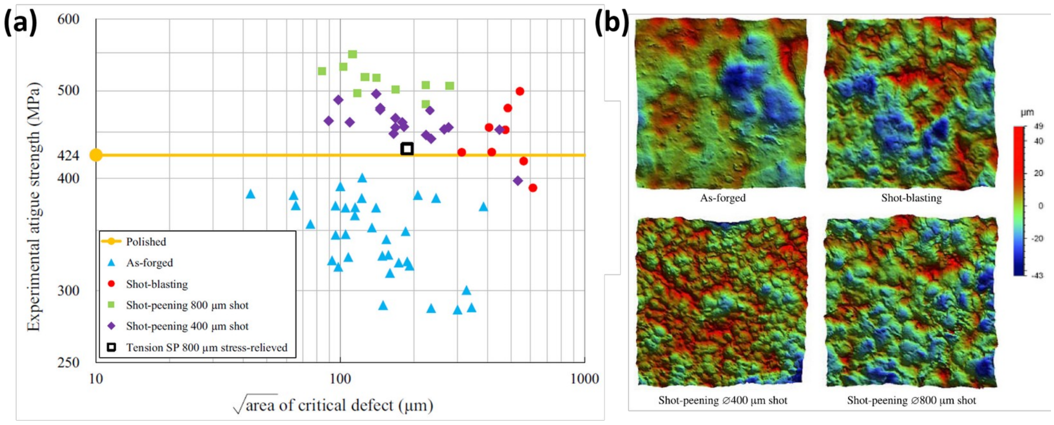
Short description of possible research topics for a PhD: Surface treatments (coating, shot peening, sandblasting, nitriding) aim to modify the properties (chemical, mechanical, ...) on the surface or subsurface of a part in order to improve its initial characteristics by creating a microstructure gradient associated with a residual mechanical field (Fabre et al. 2013; Klotz et al. 2018). This type of process is used in many industrial fields (aeronautics, automotive, ...), on very diverse critical parts (turbine disks, gears, connecting rods...) (Gerin et al. 2017). A fine characterization of the impact of surface treatments on the improvement of part performance is paramount for safety issues, optimization of their shape and process parameters. This project aims to contribute to the understanding of damage mechanisms observed during contact fatigue. It will develop new experiments to characterize the integrity of surfaces with gradients in properties during repeated cycles between a sphere and the part. Damage monitoring will be performed using different characterization techniques (DIC, SEM, EBSD, XRD) (Stinville et al. 2016). Particular attention will be paid to define a representative volume of macroscopic damage with the different characterization techniques used. To the experimental tests, a modeling of the test will be coupled in order to better understand the mechanisms at the origin of the damage of the studied parts.

Required background of the student: material and mechanics

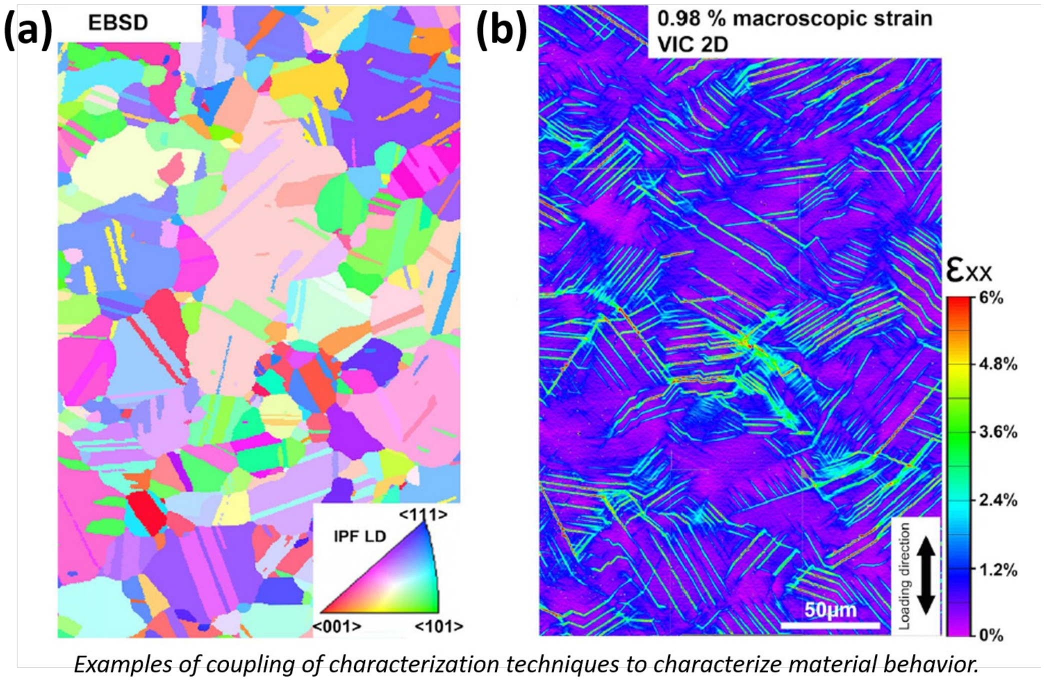
A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Fabre, A., H.P. Evans, L. Barrallier, K.J. Sharif, and M. Desvignes. 2013. "Prediction of Microgeometrical Influences on Micropitting Fatigue Damage on 32CrMoV13 Steel." Tribology International 59 (March): 129–40. https://doi.org/10.1016/j.triboint.2012.07.018.
2. Gerin, B., E. Pessard, F.Morel, and C. Verdu. 2017. "Influence of Surface Integrity on the Fatigue Behaviour of a Hot-Forged and Shot-Peened C70 Steel Component." Materials Science and Engineering: A 686: 121–33. https://doi.org/10.1016/j.msea.2017.01.041.
3. Klotz, T., D. Delbergue, P. Bocher, M. Lévesque, and M. Brochu. 2018. "Surface Characteristics and Fatigue Behavior of Shot Peened Inconel 718." International Journal of Fatigue 110 (May): 10–21. https://doi.org/10.1016/j.ijfatigue.2018.01.005.
4. Stinville, J.C., P. Echlin, Damien Texier, F. Bridier, P. Bocher, and T.M. Pollock. 2016. "Sub-Grain Scale Digital Image Correlation by Electron Microscopy for Polycrystalline Materials during Elastic and Plastic Deformation." Experimental Mechanics 56 (2): 197–216. https://doi.org/10.1007/s11340-015-0083-4.
5.

Illustrations :



Examples of surface treatments influence. a) Kitagawa diagram of the fatigue tests, *b) Close-ups of surface scans of the specimens after different surface treatments (Gerin et al. 2017)*



Examples of coupling of characterization techniques to characterize material behavior. a) EBSD measurements, b) strain field xx from DIC measurements (Stinville, 2016)

TITLE:INNOVATIVE DESIGN FOR ADDITIVE MANUFACTURING THROUGH KNOWLEDGE MANAGEMENT AND TRIZ

Topic number : ***2021_043***

Field : Design, Industrialization

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: SIADAT Ali ali.siadat@ensam.eu
Advisor 2: Hassan Alaa alaa.hassan@univ-lorraine.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Additive manufacturing (AM) offers significant opportunities for product innovation in many fields. The Design for Additive Manufacturing (DfAM) approach could be considered as a guideline for the design team in the early phase of the product development process. However, AM is becoming a data-intensive activity and the design of a new product can be facilitated by using previous knowledge from successful projects and the literature. This relevant knowledge is not easy to find or reuse. The theory of inventive problem solving methodology (TRIZ) is a well-established accelerator to support problem solving by linking specific engineering problems and solutions to general patterns and laws. TRIZ method can be coupled with a well-structured knowledge base (KB) in order to build a DfAM support system that helps the engineers in finding the most suitable rules and constraint-solving principles to fully exploit the potential of AM. The objectives of this PhD proposal are 1) To develop a KB in order to capture and structure the DfAM principles and knowledge Web Ontology Language (OWL) or System Modelling Language (SysML) could be used to develop this KB, and 2) To integrate the TRIZ inventive principles into the KB in order to build DfAM support system. Artificial Intelligence could be used to map the problem space to the solution space and to retrieve the relevant information.

Required background of the student:

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. T. J. Hagedorn, S. Krishnamurty, and I. R. Grosse, "A Knowledge-Based Method for Innovative Design for Additive Manufacturing Supported by Modular Ontologies," J. Comput. Inf. Sci. Eng., vol. 18, no. 2, pp. 1–12, 2018.
2. S. Kadkhoda-Ahmadi, A. Hassan, and E. Asadollahi-Yazdi, "Process and resource selection methodology in design for additive manufacturing," Int. J. Adv. Manuf. Technol., vol. 104, no. 5–8, pp. 2013–2029, 2019.
3. U. K. uz Zaman, M. Rivette, A. Siadat, and S. M. Mousavi, "Integrated product-process design: Material and manufacturing process selection for additive manufacturing using multi-criteria decision making," Robot. Comput. Integr. Manuf., vol. 51, no. December 2017, pp. 169–180, 2018.
4. N. Kretzschmar and S. Chekurov, "The applicability of the 40 TRIZ principles in design for additive manufacturing," Ann. DAAAM Proc. Int. DAAAM Symp., vol. 29, no. 1, pp. 888–893, 2018.
5. L. Liu, Y. Li, Y. Xiong, and D. Cavallucci, "A new function-based patent knowledge retrieval tool for conceptual design of innovative products," Comput. Ind., vol. 115, p. 103154, 2020.

Illustrations :

illustration Arts et Métiers ParisTech_ERPI_LCFC_HASSAN_SIADAT 2021

TITLE:FLUID DYNAMIC UNSTEADINESS IN MULTIPHASE TURBOMACHINERY

Topic number : ***2021_044***

Field : Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:Rotating Flows https://lmfl.cnrs.fr/en/research/th2-rotating-flows/
Research lab: LMFL - Laboratoire de mécanique des fluides de Lille
Lab location: Lille
Lab website:https://lmfl.cnrs.fr/en/home/

Contact point for this topic: Arts et Métiers

Advisor 1: Dazin Antoine antoine.dazin@ensam.eu
Advisor 2: Romano Francesco francesco.romano@ensam.eu
Advisor 3:
Advisor 4:

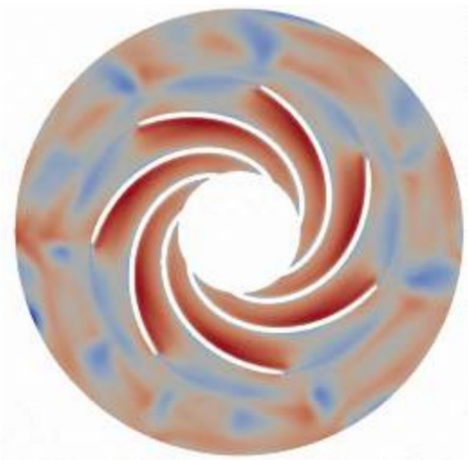
Short description of possible research topics for a PhD: Rotating flows in centrifugal pumps operating at partial flow rates could experience unsteady phenomena (boundary layer detachment, rotating stall ...) leading to a decay of their operational performance (see figures below). The presence of static and rotating parts, with a typically complex geometry, induces a complex base flow and makes difficult to predict and characterize these flow unsteadiness. Such phenomena become even more complex when a two-phase flow is considered. In this project an air-water multiphase flow is considered, with the aim to investigate how the interplay between the two phases participating in the turbomachinery flow changes the nature of the unsteadiness and affects the performances. Both, numerical simulations and experiments will be carried out in this project.

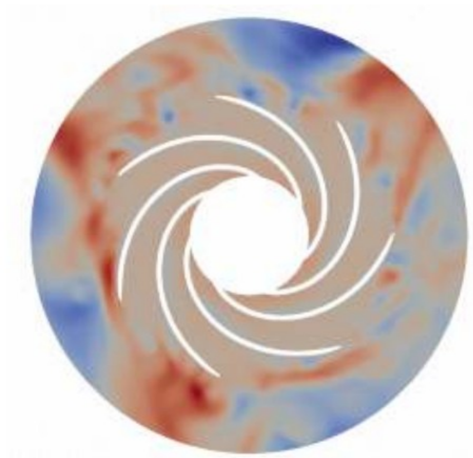
Required background of the student: Master of Science in Fluid Mechanics or equivalent

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Dazin, A., Cavazzini, G., Pavesi, G. et al. High-speed stereoscopic PIV study of rotating instabilities in a radial vaneless diffuser. Exp Fluids 51, 83–93 (2011). https://doi.org/10.1007/s00348-010-1030-x
2. Y. Heng, A. Dazin, M. N. Ouarzazi, and Q. Si. Experimental study and theoretical analysis of the rotating stall in a vaneless diffuser of radial flow pump. IOP Conference Series : Earth and Environmental Science, 49 :032006, 2016
3. Y. Heng, A. Dazin, M. N. Ouarzazi, and Q. Si. A study of rotating stall in a vaneless diffuser of radial flow pump. J. Hyd. Res., 56 :494–504, 2018.
4. Liao, M.; Si, Q.; Fan, M.; Wang, P.; Liu, Z.; Yuan, S.; Cui, Q.; Bois, G. Experimental Study on Flow Behavior of Unshrouded Impeller Centrifugal Pumps under Inlet Air Entrainment Condition. Int. J. Turbomach. Propuls. Power 2021, 6, 31.
https://doi.org/10.3390/ijtpp6030031
5.

Illustrations :





TITLE:DEVELOPMENT AND OPTIMIZATION OF TOOL DESIGN/GEOMETRY FOR DRILLING AEROSPACE ALLOYS USING LCO2 AND OTHER ENVIRONMENTALLY FRIENDLY METALWORKING FLUIDS

Topic number* : *2021_045

Field : Energy, Processes, Material science, Mechanics and Fluids

Subfield: Mechanical Engineering, Manufacturing Processes, Fluid dynamics

ParisTech School: Arts et Métiers
Research team:High Speed Machining
Research lab: LABOMAP - Laboratoire Bourguignon des matériaux et procédés
Lab location: Cluny
Lab website:http://labomap.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: OUTEIRO Jose jose.outeiro@ensam.eu
Advisor 2: Deligant Michael michael.deligant@ensam.eu
Advisor 3: Rossi Frédéric frederic.rossi@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: Because 36% of all the machine time is spend performing drilling operations, the use of high-performance drilling tools can reduce the drilling time and cost. Unfortunately, practically all drills used today in industry have problems with excessive wear/low tool life due to their suboptimal designs including the particularities of coolant supply. Recent drilling tests using a newly designed drill with peripherical coolant holes (located at the corners region), conducted at an automotive shop floor, have shown an increase of tool life up to 8 times when compared to the traditional drill. Further improvement of the performance of the proposed design are needed to achieve its full potential.
The main objective of this Ph.D proposal is to significantly increase tool life and quality of the drilled holes (both surface roughness and shape) in drilling difficult-to-cut aerospace alloys using liquid CO2 (LCO2) and other environmentally friendly metalworking fluids through the optimization of the drill design/geometry. To achieve this objective, drilling simulations using different numerical approaches (including Coupled Eulerian-Lagrangian) and considering fluid flow will be

developed. Experimental drilling tests of aerospace alloys will be conducted to validate such model. Both simulated and experimental data will be used in artificial intelligence and optimization algorithms to find the optimal tool geometry parameters.

Required background of the student: We are looking for a highly motivated candidate with a Master's degree in Mechanical Engineering. A knowledge of the finite element method, fluid mechanics and heat transfer will be considered a strong merit. Other desirable knowledge/experience but not essential includes manufacturing processes.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. X. Xu, J.C. Outeiro, J. Zhang, B. Xu, W. Zhao, "Machining simulation of Ti6Al4V using coupled Eulerian-Lagrangian approach and a constitutive model considering the state of stress", Simulation Modelling Practice and Theory, Vol. 110, pp. 102312, 2021.
2. A. Attanasio, E. Ceretti, J.C. Outeiro, G. Poulachon, Numerical Simulation of Tool Wear in Drilling Inconel 718 under Flood and Cryogenic Cooling Conditions, Wear, Vol. 458–459, pp. 203403, 2020.
3. J.C. Outeiro, P. Lenoir, A. Bosselut, "Thermo-Mechanical Effects in Drilling Using Metal Working Fluids and Cryogenic Cooling and their Impact in Tool Performance", Production Engineering, Research and Development, Springer, Vol. 9, pp 551–562, 2015.
4. M. Deligant, M. Specklin, and S. Khelladi. A naturally anti-diffusive compressible two phases kapila model with boundedness preservation coupled to a high order finite volume solver. Computers and Fluids, 114, 2015.
5. M. Specklin, M. Deligant, S. Porcheron, M. Wagner, F. Bakir Experimental study and modelling of a high-pressure ratio liquid piston compressor. HEFAT 2019, Wicklow, Ireland.

Illustrations :

TITLE:INTEGRATED VIRTUAL SIMULATION AND VISUALIZATION OF MANUFACTURING PROCESSES USING NUMERICAL SIMULATION AND AUGMENTED REALITY

Topic number* : *2021_046

Field : Information and Communication Science and Technology, Material science, Mechanics and Fluids

Subfield: Manufacturing Processes, Augmented Reality, Virtual Reality and Mixed Reality

ParisTech School: Arts et Métiers
Research team:High Speed Machining
Research lab: LABOMAP - Laboratoire Bourguignon des matériaux et procédés
Lab location: Cluny
Lab website:http://labomap.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: OUTEIRO Jose jose.outeiro@ensam.eu
Advisor 2: Chardonnet Jean-Rémy jean-remy.chardonnet@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The 4th industrial revolution (Industry 4.0) is characterized by a fusion of technologies which erases the border between the real and virtual worlds. We are assisting to an exponential penetration of the digital technologies into the manufacturing industry. Nowadays, numerical simulation if often used for predicting manufacturing processes performance and part quality, aiming for optimizing and reducing their cost. To completely merging these two worlds and take advantage of both experimental data acquired by sensors connected to the process and simulation data from robust physical models, the simultaneous visualization of both data in an immersive environment is necessary.
The objective of this Ph.D proposal is twofold. First, to develop robust physical models of real machining operations (turning, milling, and drilling) using recent advances on numerical simulation. Second, to develop augmented and virtual reality applications allowing simultaneous adaptive and intuitive real-time visualization of simulation and experimental data during a real machining operation.

Required background of the student: We are looking for a highly motivated candidate with a Master's degree in Mechanical Engineering or Computer Science. A knowledge of the finite element method and C++/C# programming languages will be considered a strong merit. Other desirable knowledge/experience but not essential includes manufacturing processes and real-time application development and mixed reality.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. X. Xu, J.C. Outeiro, J. Zhang, B. Xu, W. Zhao, "Machining simulation of Ti6Al4V using coupled Eulerian-Lagrangian approach and a constitutive model considering the state of stress", Simulation Modelling Practice and Theory, Vol. 110, pp. 102312, 2021.
2. A. Attanasio, E. Ceretti, J.C. Outeiro, G. Poulachon, Numerical Simulation of Tool Wear in Drilling Inconel 718 under Flood and Cryogenic Cooling Conditions, Wear, Vol. 458–459, pp. 203403, 2020.
3. M. Ghinea, D. Frunza, J.-R. Chardonnet, F. Merienne, and A. Kemeny, "Perception of Absolute Distances within Different Visualization Systems: HMD and CAVE," in 5th International Conference on Augmented Reality, Virtual Reality, and Computer Graphics, Otranto, Italy, Jun. 2018, vol. 10850, pp. 148–161.
4. J.-R. Chardonnet, G. Fromentin, and J. Outeiro, "Augmented reality as an aid for the use of machine tools," Research and Science Today, vol. Supplement No. 2, pp. 25–31, Oct. 2017.
5. F. Ababsa, J. He, and J.-R. Chardonnet, "Combining HoloLens and Leap-Motion for Free Hand-Based 3D Interaction in MR Environments," in 7th International Conference on Augmented Reality, Virtual Reality, and Computer Graphics, Online, Sep. 2020, vol. 12242, pp. 315–327.

Illustrations :

Title:Single and Multiple Cavitating Bubbles near a Wall

Topic number : ***2021_048***

Field : Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:Rotating Flows https://lmfl.cnrs.fr/en/research/th2-rotating-flows/
Research lab: LMFL - Laboratoire de mécanique des fluides de Lille
Lab location: Lille
Lab website:https://lmfl.cnrs.fr/en/home/

Contact point for this topic: Arts et Métiers

Advisor 1: Romano Francesco francesco.romano@ensam.eu
Advisor 2: Coutier-Delgosha Olivier olivier.coutier-delgosha@ensam.eu
Advisor 3: Dazin Antoine antoine.dazin@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: Cavitation is among the most studied phenomena in classic and modern fluid mechanics. It strongly affects the performance of engineering designs such as hydraulic turbomachineries and pumps and it encompasses a complex physics that is best investigated studying the behaviour of a cavitating bubble near a wall. In this project aim at unravelling the role of temperature, pressure waves, microjets and bubble composition in cavitation erosion. Promising predictive tools are represented by modern CFD solvers, extensively tested against experiments for a relevant collapsing bubble configuration, see figures below. The experimental activity is carried out at VirginiaTech. The numerical simulations will be performed at Art et Metiers, Lille. Several regimes will be investigated to understand the impact of several parameters like the composition of the bubble, the temperature and pressure conditions at which the cavitation occurs, as well as the properties of the wall.

Required background of the student: Master of Science in Fluid Mechanics or equivalent

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Chebli, R., Audebert, B., Zhang, G., Coutier-Delgosha, O. Influence of the turbulence modeling on the simulation of unsteady cavitating flows.

Computers and Fluids, 2021, 221, 104898

2. Zhang, X.-L., Ge, M.-M., Zhang, G.-J., Coutier-Delgosha, O. Compressible effects modeling for turbulent cavitating flow in a small venturi channel: An empirical turbulent eddy viscosity correction. Physics of Fluids, 2021, 33(3), 035148

3. Hamdi, M., Coutier-Delgosha, O., & Baudoin, M. (2018). Measurements of the temperature variations during the growth and collapse of cavitation bubbles. Proceedings of the 10th International Symposium on Cavitation (CAV2018), ASME. https://doi.org/10.1115/1.861851

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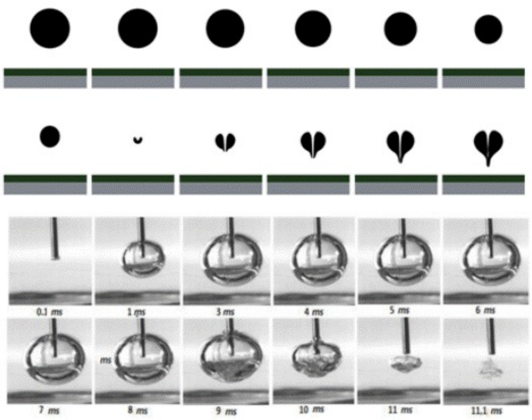
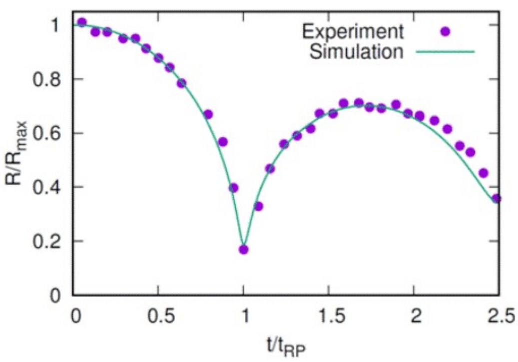
Illustrations :





TITLE:ROBUST ROBOTIC GRINDING CONTROL TO TAKE INTO ACCOUNT PROCESS VARIABILITY

Topic number : ***2021_052***

Field : Design, Industrialization

Subfield: Robotics & Manufacturing

ParisTech School: Arts et Métiers
Research team:Manufacturing & Control Command http://lcfc.ensam.eu
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: BIGOT Régis regis.bigot@ensam.eu
Advisor 2: RAHARIJAONA Thibaut thibaut.raharijaona@univ-lorraine.fr
Advisor 3: CHEVRET Sandra sandra.chevret@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: The robotization of the grinding allows to reduce musculoskeletal disorders (MSD), to reduce operator injuries and allows mass production grinding and ensures repeatability of quality. The objective is to develop a robotic grinding control system able of grinding parts while controlling the grinding depth, the number of passes and obtaining the required surface finish. The work will have to allow the grinding of complex geometries with different wheel diameters and to take into account the geometrical variations of the grinding wheel during the operation. This is due to the fact that the wear of the grinding wheel affects its diameter and consequently the rate of material removal and the position of the Tool Center Point (TCP- which is generally defined at the end of the wheel). So, due to wear, the wheel diameter do not remain constant over the process. To optimize the grinding conditions of several parts it is necessary to model the variation of the grinding wheel diameter as a function of wear to enable the prediction of the grinding surface dimensions and the obtained surface roughness. To succeed a mathematically modeled is needed and will be implemented firstly to simulate the process and finally experimentally. Finally, in order to guarantee a homogeneous surface condition over the entire length of the grinding process, it is necessary to develop strategies for the entry into contact between the workpiece and the grinding wheel and for the end of the grinding process, as the grinding wheel releases the surface. These two stages, beginning and end of grinding, often lead to slight undesired steps. The whole PhD work will be developed on an experimental robotized system (ABB robot) with a Ferrobotic head.

Required background of the student: Knowledge in robotics; manufacturing (grinding) if possible; Programming ; applied mechanics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Kolegain, K., Leonard, F., Chevret, S., Attar, A. B., & Abba, G. (2018). Off-line path programming for three-dimensional robotic friction stir welding based on Bézier curves. Industrial Robot: An International Journal.
2. Chaoui, M. D., Léonard, F., & Abba, G. (2019). Improving surface roughness in robotic grinding process. In ROMANSY 22–Robot Design, Dynamics and Control (pp. 363-369). Springer, Cham.
3. Wang, Z., Zimmer-Chevret, S., Léonard, F., & Abba, G. (2021). Prediction of bead geometry with consideration of interlayer temperature effect for CMT-based wire-arc additive manufacturing. Welding in the World, 1-12.
4. Venet, G., Baudouin, C., Pondaven, C., Bigot, R., & Balan, T. (2021). Parameter identification of 42CrMo4 steel hot forging plastic flow behaviour using industrial upsetting presses and finite element simulations. International Journal of Material Forming, 1-17
5. Wilfrido, P. Q. C., Gabriel, A., Jean-Francois, A., Thibaut, R., & Philippe, G. (2021). Load-dependent Friction Laws of Three Models of Harmonic Drive Gearboxes Identified by Using a Force Transfer Diagram. 12th International Conference on Mechanical and Aerospace Engineering (ICMAE) (pp. 239-244). IEEE.

Illustrations :

illustration Robotic Grinding PhD proposal_LCFC_2021

TITLE:AUTOMATION OF A FLEXIBLE AND AGILE FINISHING PROCESS OF FORGED WORKPIECES WITH INDUSTRIAL ROBOTS

Topic number : ***2021_054***

Field : Design, Industrialization

Subfield: Manufacturing

ParisTech School: Arts et Métiers
Research team:Manufacturing http://lcfc.ensam.eu
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: BALAN Tudor tudor.balan@ensam.eu
Advisor 2: BAUDOUIN Cyrille cyrille.baudouin@ensam.eu
Advisor 3: CHEVRET Sandra sandra.chevret@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: Grinding is necessary to remove overage parts from forged workpieces (flash, surface imperfections, oxide incrustation, etc.). Finishing processes of large forged workpieces are still done manually in most cases. Automation of the finishing process is expected to eliminate the hard manual operations that can lead to musculoskeletal disorders and productivity decrease. Greater accuracy and repeatability of operations is expected. However, at the end of a forging operation, each part is unique, and is the image of the accumulation of all process variabilities. The artificial intelligence would be able to control the robot to perform grinding according to observations made on the workpiece. In the meantime, this PhD consists in creating and deploying a methodology that would allow an effective collaboration between the observation of a workpiece, the interpretation made by an operator and the realization of the expected operations by a robot in a context of industrial productivity. The robot must be able to understand human-like instructions (by gesture, graphics or digital interface). The robotic grinding must also be able to provide a desired geometry or surface roughness despite variations originating from the upstream phases of the process. Robotic grinding has to be able to master the interactions between grinding tool and material, vibrations, robot paths, and forces applied during grinding.

Required background of the student: Knowledge in robotics; manufacturing (grinding) if possible; programming; applied mechanics; mathematics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Zimmer, S., Langlois, L., Laye, J., & Bigot, R. (2010). Experimental investigation of the influence of the FSW plunge processing parameters on the maximum generated force and torque. The International Journal of Advanced Manufacturing Technology, 47(1), 201-215.
2. Chaoui, M. D., Léonard, F., & Abba, G. (2019). Improving surface roughness in robotic grinding process. In ROMANSY 22–Robot Design, Dynamics and Control (pp. 363-369). Springer, Cham.
3. Wang, Z., Zimmer-Chevret, S., Léonard, F., & Abba, G. (2021). Prediction of bead geometry with consideration of interlayer temperature effect for CMT-based wire-arc additive manufacturing. Welding in the World, 1-12.
4. Venet, G., Baudouin, C., Pondaven, C., Bigot, R., & Balan, T. (2021). Parameter identification of 42CrMo4 steel hot forging plastic flow behaviour using industrial upsetting presses and finite element simulations. International Journal of Material Forming, 1-17
5. Yang, Y., Vincze, G., Baudouin, C., Chalal, H., & Balan, T. (2021). Strain-path dependent hardening models with rigorously identical predictions under monotonic loading. Mechanics Research Communications, 114, 103615.

Illustrations :

illustration Grinding PhD project_LCFC_2021

TITLE:SENSORLESS CONTROL FOR INTEGRATED MULTIPHASE DRIVES APPLIED TO TRANSPORTATION SYSTEMS USING ARTIFICIAL INTELLIGENCE POTENTIALITY

Topic number* : *2021_055

Field : Energy, Processes

Subfield: Electrical Engineering and Automation Control

ParisTech School: Arts et Métiers
Research team:Control Team of L2EP Lab
http://l2ep.univ-lille.fr/en/groupes-de-recherche/equipe-commande/
Research lab: L2EP - aboratoire d'Electrotechnique et électronique de puissance
Lab location: Lille
Lab website:http://l2ep.univ-lille.fr

Contact point for this topic: Arts et Métiers

Advisor 1: NGUYEN Ngac Ky ngacky.nguyen@ensam.eu
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: This project aims to study a compact and performant integrated multiphase drive, including fault modes, for automotive mass market. In this context, price, reliability and compacity are the main criteria. Among the sensors, the end-shaft mechanical position sensor is the most expensive one and is consuming space. Using only current measurement could lead to a suppression of the end-shaft position sensor. Sensorless control algorithms have been proposed for three-phase drives since several decades with the increase of power calculation for signal processing. With multiphase machines, it is possible to use additionally magnetic sensors to increase the number of data of the rotor position which will be used for vector control even in fault modes.
Artificial Intelligence (AI) will be investigated for sensorless algorithm development. With multiphase machines using numerous current and magnetic sensors, we propose, by coupling AI with expert knowledges on electrical multiphase machines, to obtain reliable and real-time estimation of the rotor position for a use in the vector control in healthy but also in fault mode operation.

Required background of the student: Beside a good level of English, the recruited student must have:
- A strong background of electrical machines
- A good general culture of scientific research, i.e a Master Research Diploma is helpful
- A good skill for working autonomously and within a team

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. 4. Y. Mini, N. K. Nguyen, E. Semail, “A novel Sensorless Control Strategy Based on Sliding Mode Observer for Non-Sinusoidal Seven-phase PMSM”, The 10th International Conference on Power Electronics, Machines and Drives, December 2020.
2. 5. D. A. T. Guzman, N. K. Nguyen, M. Trablesi, and E. Semail, "Low Speed Sensorless Control of Non-Salient Poles Multiphase PMSM," in 2019 IEEE International Conference on Industrial Technology (ICIT), 2019, pp. 1563-1568.
3. 3. N. K. Nguyen, E. Semail, F. D. Belie, and X. Kestelyn, "Adaline Neural Networks-based sensorless control of five-phase PMSM drives," in IECON 2016 - 42nd Annual Conference of the IEEE Industrial Electronics Society, 2016, pp. 5741-5746.
4.
5.

Illustrations :

illustration N K Nguyen - CSC Proposition 2021 for PhD Study in Electrical Engineering

TITLE:IMPROVING FORMABILITY OF LIGHTWEIGHT METALLIC MATERIALS USING PROCESS CHAINING: INCREMENTAL FORMING AND FRICTION STIR WELDING

Topic number : ***2021_061***

Field : Material science, Mechanics and Fluids

Subfield: Mechanical, Material and Process Engineering

ParisTech School: Arts et Métiers
Research team:
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location: Angers
Lab website:http://lampa.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: DAL SANTO Philippe philippe.dalsanto@ensam.eu
Advisor 2: TIBA Idriss idriss.tiba@ensam.eu
Advisor 3: CHEVRET Sandra sandra.chevret@ensam.eu
Advisor 4: BALAN Tudor tudor.balan@ensam.eu

Short description of possible research topics for a PhD: The current trends of the “industry of the future” include dramatic product customization (small batch production) along with optimized lightweight construction, in particular in transportation industries. Innovative technologies to answer these challenges, include robotized forming and assembly processes like single point incremental forming (SPIF) and friction stir welding (FSW), in conjunction with sheet aluminum alloys. Developed during the last two decades, these promising processes still exhibit numerous scientific and technological challenges. Process chaining, on the same part and robot, would allow for a deeper optimization at an improved cost, allowing for the right material at the right place; however the impact of assembly on the residual formability is little known. Establishing the relationship between process parameters and part quality after welding and further forming would be a significant achievement. Controlling the sheet temperature is one of the promising directions to further improve the formability. The final objective is to propose a numerical approach to simulate the forming processes including the chaining effects. Depending on the abilities of the candidate, one or the other of these research directions will be further developed.

Required background of the student: The student must have very good knowledge in forming processes of metallic materials and in numerical simulation. Some background in metallurgy will be also appreciated.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. D. Rou et al. Experimental and numerical investigation of the mechanical behavior of the AA5383 alloy at high temperatures. Journal of Materials Processing Technology (2020), 281; art. no. 116609.
2. Y. Yang and T. Balan. Prediction of the yield surface evolution and some apparent non normality effects after abrupt strain-path change using classical plasticity. Int. Journal of Plasticity (2019), 119; 331-343.
3. S. Boudhaouia et al. Experimental and numerical study of a new hybrid process: multi-point incremental forming (MPIF). International Journal of Material Forming (2018), 11; 815–827.
4. K. Kolegain et al. Off-line path programming for three-dimensional Robotic Friction Stir Welding based on Bézier curves. Industrial Robot: An International Journal (2018).
5.

Illustrations :

TITLE:SMART AND MULTIPHYSICS SOLID-SHELL FINITE ELEMENTS FOR THE SIMULATION OF 3D THIN STRUCTURES

Topic number : ***2021_062***

Field : Material science, Mechanics and Fluids

Subfield: Mechanical Engineering

ParisTech School: Arts et Métiers
Research team:Numerical Methods, Instabilities and Vibrations
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.univ-lorraine.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: ABED-MERAIM Farid Farid.Abed-Meraim@ensam.eu
Advisor 2: CHALAL Hocine Hocine.chalal@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: In nowadays manufacturing industry, thin structures are widely designed and employed to reduce weight of products, while improving their mechanical performances (strength, crashworthiness ...). The simulation of these thin structures using the finite element method has become more and more important in the design and manufacture processes. In our research group, we have recently developed a family of solid-shell finite elements, which are capable of modeling most 3D thin structural problems using only a single element layer, while accurately describing the various through-thickness phenomena. The purpose of the present PhD thesis is to pursue the previous works on the development of solid‑shell elements, by extending their formulations to advanced and multiphysics constitutive laws for the simulation of manufacturing processes. More specifically, coupled magnetic-elastic-plastic constitutive laws will be combined with the developed solid‑shell elements for the simulation of magnetic pulse forming processes. Also, strong thermomechanical coupling, involving the addition of temperature degrees of freedom, will be considered in the formulation of the solid‑shell finite elements, for the simulation of warm and hot sheet metal forming processes.

Required background of the student: - Solid background in finite element formulation and simulation;
- Good analytical and programming skills (e.g., Fortran, C, C++);

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Abed-Meraim F, Combescure A (2009). An improved assumed strain solid‒shell element formulation with physical stabilization for geometric non-linear applications and elastic–plastic stability analysis. International Journal for Numerical Methods in Engineering, 80:1640–1686.
2. Wang P, Chalal H, Abed-Meraim F (2015). Efficient solid‒shell finite elements for quasi-static and dynamic analyses and their application to sheet metal forming simulation. Key Engineering Materials, 651–653:344–349.
3. Wang P, Chalal H, Abed-Meraim F (2017). Quadratic solid–shell elements for nonlinear structural analysis and sheet metal forming simulation. Computational Mechanics, 59:161–186.
4. Wang P, Chalal H, Abed-Meraim F (2017). Quadratic prismatic and hexahedral solid–shell elements for geometric nonlinear analysis of laminated composite structures. Composite Structures, 172:282–296. 1.
5. Chalal H, Abed-Meraim F (2018). Quadratic solid-shell finite elements for geometrically nonlinear analysis of functionally graded material plates. Materials, 11(6), art. no. 1046.

Illustrations :

illustration CSC 2021 Sujet N° 1 HC

TITLE:TOWARDS THE DEFINITION OF INDUSTRY 4.0 AND 5.0 KEY PERFORMANCE INDICATORS

Topic number : ***2021_063***

Field : Information and Communication Science and Technology

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LISPEN - Laboratoire d'ingénierie des systèmes physiques et numériques
Lab location: Lille
Lab website:https://lispen.ensam.eu/

Contact point for this topic: Arts et Métiers

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Advisor 4:

Short description of possible research topics for a PhD: The Industry4.0 context drives the manufacturing companies towards the implementation of Reconfigurable Manufacturing Systems (RMS) enabling agility. In this context, assessing the performance of such systems becomes even more crucial. Generally, this requires to define a set of relevant KPIs (Key Performance Indicator) like these defined in the ISO 22400 standard and to manage them preferably on-line and dynamically.
Several indicators should be defined to help the manager to monitor his system: indicators about reconfigurabitility or performance indicators. For instance, these indicators could help the manager to decide how to reconfigure his system, or simply to modify the allocation of resources.

Nowadays, thanks to Industry 4.0 new concepts such as decentralized control system, many information, data, are available at any moment and everywhere. How to exploit these data to better define the considered system, follow it through a dashboard, help the manager to take the right decision at the right time? This can be done through Cyber Physical Production System.
Therefore, the objective of this PhD would be to define what could be

“I4.0 KPIs” that is to say which should be the relevant set of KPIs for RMSs and how to manage them dynamically that is to say how to make them change according to the system configuration.

Required background of the student: Industrial engineering, Information system, operational research

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Wu, X., Goepp, V., Siadat, A. “Concept and engineering development of cyber physical production systems: a systematic literature review” International Journal of Advanced Manufacturing Technology, 2020, 111(1-2), pp. 243-261
2. Wu, X., Goepp V., Siadat A. “The integrative link between cyber physical production systems and enterprise information systems” accepted to the 49th International Conference on Computers & Industrial Engineering conference (CIE 49), October 18-21, 2019, Beihang University, Beijing, China
3. Nieto, F. D. M., V. Goepp and E. Caillaud (2017). "From Factory of the Future to Future of the Factory: Integration Approaches." Ifac Papersonline 50(1): 11695-11700
4. Beauville dit Eynaud, A., Klement, N., Roucoules, L. et al. Framework for the design and evaluation of a reconfigurable production system based on movable robot integration. Int J Adv Manuf Technol (2021). https://doi.org/10.1007/s00170-021-08030-1
5. Amzil K., Yahia E., Klement N., Roucoules L. (2021) Causality Learning Approach for Supervision in the Context of Industry 4.0. In: Roucoules L., Paredes M., Eynard B., Morer Camo P., Rizzi C. (eds) Advances on Mechanics, Design Engineering and Manufacturing III. JCM 2020. Lecture Notes in Mechanical Engineering. Springer, Cham. https://doi.org/10.1007/978-3-030-70566-4_50

Illustrations :

TITLE:FORMING LIMIT PREDICTIONS FOR POROUS MATERIALS IN COLD AND WARM SHEET METAL FORMING

Topic number : ***2021_064***

Field : Material science, Mechanics and Fluids

Subfield: Mechanical Engineering

ParisTech School: Arts et Métiers
Research team:Numerical Methods, Instabilities and Vibrations
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.univ-lorraine.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: ABED-MERAIM Farid Farid.Abed-Meraim@ensam.eu
Advisor 2: CHALAL Hocine Hocine.chalal@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: In the context of sheet metal forming, the occurrence of diffuse and localized necking, which are precursors to ductile fracture, represents one of the main causes for rejection of metal parts during forming operations. In order to accurately predict the occurrence of these defects, various theoretical and numerical approaches have been developed in the literature. These approaches require, on the one hand, the introduction of appropriate constitutive models in order to reproduce the physical phenomena involved during forming operations. On the other hand, the selected constitutive models have to be combined with necking criteria for the prediction of plastic instabilities, such as diffuse and localized necking, in thin sheet metal forming. The purpose of the present PhD thesis is to combine advanced elastic-plastic-damage models with necking criteria for the prediction of formability limits of ductile materials. The resulting numerical tool is then applied for the prediction of forming limits of ductile materials under cold and warm forming conditions.

Required background of the student: - Solid background in mechanic of materials and finite element simulation;
- Good analytical and programming skills (e.g., Fortran, C, C++);

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Nasir M W, Chalal H, Abed-Meraim F (2021). Formability prediction using bifurcation criteria and GTN damage model. International Journal of Mechanical Sciences, 191:106083.
2. Nasir MW, Chalal H, Abed-Meraim F (2020). Prediction of forming limits for porous materials using void-size dependent model and bifurcation approach. Meccanica, 55(9):1829–1845.
3. Bouktir Y, Chalal H, Abed-Meraim F (2018). Prediction of necking in thin sheet metals using an elastic–plastic model coupled with ductile damage and bifurcation criteria.. International Journal of Damage Mechanics, 27(6):801–839.
4. Chalal H, Abed-Meraim F (2017). Numerical predictions of the occurrence of necking in deep drawing processes. H. Chalal, F. Abed-Meraim. Metals, 7(11), art. no. 455.
5. Chalal H, Abed-Meraim F (2017). Determination of forming limit diagrams based on ductile damage models and necking criteria. Latin American Journal of Solids and Structures, 14(10):1872–1892.

Illustrations :

illustration CSC 2021 Sujet N° 2 HC

TITLE:HOW TO ADAPT RECONFIGURABLE PRODUCTION SYSTEMS TO PRODUCT VARIABILITY

Topic number : ***2021_065***

Field : Design, Industrialization, Information and Communication Science and Technology

Subfield: Engineering -> Industrial Engineering

ParisTech School: Arts et Métiers
Research team:Design department
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu/

Contact point for this topic: Arts et Métiers

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Advisor 2: SIADAT Ali ali.siadat@ensam.eu
Advisor 3: STIEF Paul paul.stief@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: Today's industrial environment is still marked by an ongoing trend towards more customised products. In addition, the past years have shown an increasing instability of the worldwide economy due to an accumulation of catastrophes and crises. This very fluctuating ecosystem confronts industrial production companies with serious challenges regarding the outset of their production systems. The concept of co-evolution aims to answer these challenges.
For co-evolution, product evolution and production system evolution are put into parallel to anticipate changes of both. Also, reconfigurable systems are outset to respond exactly to the adaptability need of a product family. However, there is a lack of research work concerning the evaluation of the production system capacities to be adaptable. The research question is "how to achieve a consistency between the adaptability needs induced by product variety and the adaptability capacity provided by the production system". Figure 1(see attached files) illustrates different problematics linked to these problematics: The production system on one hand is not capable to be adapted to the entire product variety, but on the other hand has unused abilities. In a co-evolution approach, the challenge is then to orient either the product

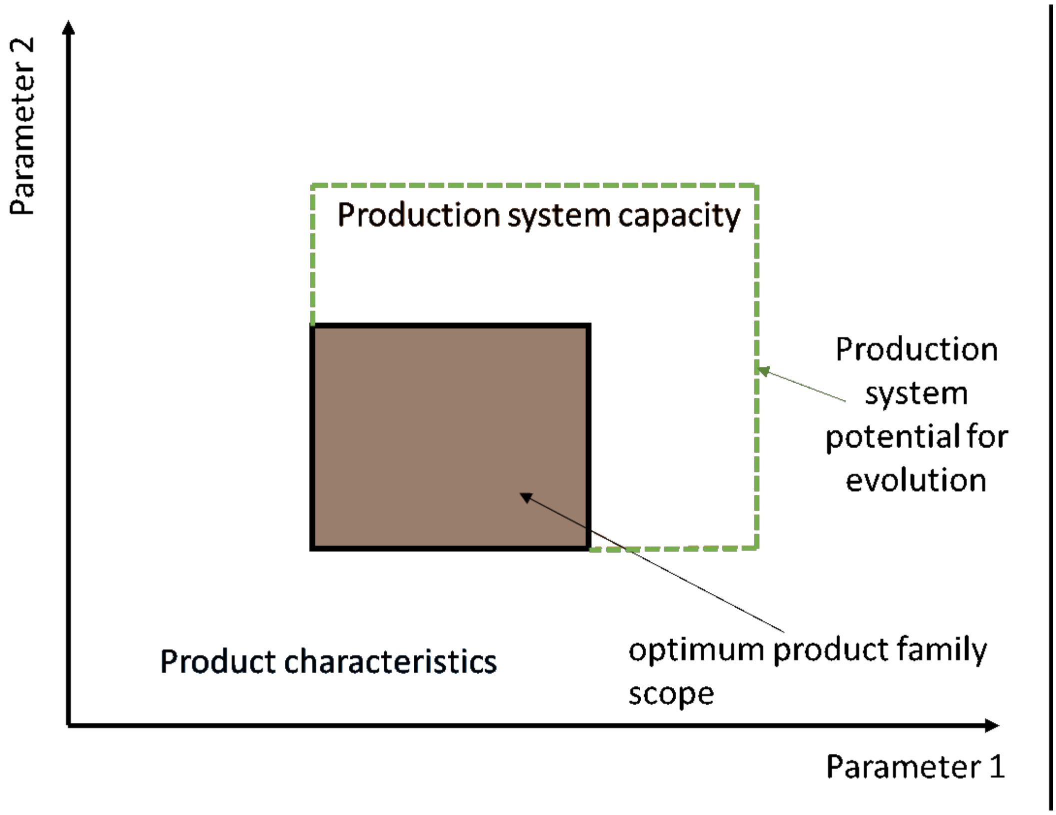
evolutions to better fit the production system abilities or to evolve the production system towards a better coverage of product variety needs. To achieve this, the thesis objective is to allow precise knowledge of production system abilities to be gathered.

Required background of the student: Industrial Engineering and/or Mechanical Engineering

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. H. A. ElMaraghy and T. AlGeddawy, 'Co-evolution of products and manufacturing capabilities and application in auto-parts assembly', Flex Serv Manuf J, vol. 24, no. 2, pp. 142–170, Jan. 2012, doi: 10.1007/s10696-011-9088-1.
2. P. Stief, J.-Y. Dantan, A. Etienne, A. Siadat, and G. Burgat, 'Product design improvement by a new similarity-index-based approach in the context of reconfigurable assembly processes', Journal of Engineering Design, vol. 31, no. 6, pp. 349–377, Jan. 2020, doi: 10.1080/09544828.2020.1748181.
3. Y. Koren, X. Gu, and Guo W., 'Reconfigurable manufacturing systems: Principles, design, and future trends', Front. Mech. Eng., vol. 13, no. 2, pp. 121–136, Jan. 2018, doi: 10.1007/s11465-018-0483-0.
4. A. M. Farid and D. C. McFarlane, 'Production degrees of freedom as manufacturing system reconfiguration potential measures', Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, vol. 222, no. 10, pp. 1301–1314, Jan. 2008, doi: 10.1243/09544054JEM1056.
5. A. M. Farid, 'Product Degrees of Freedom as Manufacturing System Reconfiguration Potential Measures', Int. Trans. on Systems Science and Applications, vol. 4, no. 3, pp. 227–242, Jan. 2008.

Illustrations :


Parameter 2
Production system capacity
Production system potential for evolution
Product characteristics
optimum product family scope
Parameter 1

Title:Contingent maintenance of instrumentation and control systems

Topic number : ***2021_066***

Field : Information and Communication Science and Technology

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Olaf Malassé olaf.malasse@ensam.eu
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Advisor 3: Frédéric Kratz frederic.kratz@insa.cvl.fr
Advisor 4:

Short description of possible research topics for a PhD: Maintaining operational conditions, within an ecosystem in tension, is a challenge that is becoming commonplace: shortage of electronic chips, maritime transport crisis ... example. In such a context, how to manage the restrictions? The management of obsolescence must therefore be rethought, system engineering must integrate the doctrines of agility, frugality and sustainability. It is eco-responsible and economically, functionally essential.
Having to reconfigure an instrumentation and control architecture to overcome a temporary shortage, accept components within the system that do not meet the original specifications, accept to see certain functionalities disappear… such will become commonplace in operational reality. The loss of functionality can also be a consequence of an islanding following, for example, a cyber attack.
Predictive maintenance and obsolescence alerts make it possible to anticipate the need, contingencies on availability can in part be anticipated. Systems engineering may, admittedly under time constraints, have time to define an acceptable compromise as to the solution to be implemented.
This is one of the functions of digital twins, a generic term if there is one. We have to think in terms of models, as well as in decision-making

capacity. Instrumentation and control systems are an intimate blend of hardware and software subassemblies and their design process is increasingly rigorous. This results in rationally distributed functionalities. What changes would require a questioning of the achievements of their IVVQ process?
System modeling will use Open Source software (selectable). A decision aid, to be designed, will make it possible to synthesize the various metrics, which will also have to be defined.

Required background of the student: control system, IT, system architecture

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Zouhri Wahb, Quality prediction/classification of a production system under uncertainty based on Support Vector Machine, Thèse de Doctorat, Paris, HESAM, École doctorale Sciences des métiers de l'ingénieur (Paris), soutenue le 10-12-2020
2. Zhao X., Malassé O., Buchheit G., Ammad N., Verification of safety integrity level of high demand system based on Stochastic Petri Nets and Monte Carlo simulation, Reliability Engineering and System Safety, n°184 pp 258-265, 2019 (Print)
3. Pascal, V., Toufik, A., Manuel, A., Florent, D., Frédéric, K., 2019. Improvement indicators for Total Productive Maintenance policy. Control Engineering Practice 82, 86–96. https://doi.org/10.1016/j.conengprac.2018.09.019
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Illustrations :

TITLE:MODELING OF METAL NANOPARTICLES EMBEDDED IN VISCOELASTIC MEDIA USING FLUID-STRUCTURE INTERACTION APPROACH

Topic number : ***2021_067***

Field : Biology, Biophysics and Biochemistry, Life and Health Science and Technology , Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:Complex Fluids and Flows
http://lampa.ensam.eu/ecoulements-complexes-132761.kjsp?RH=1415807897072&RF=1479738780674
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location: Angers
Lab website:http://lampa.ensam.eu/

Contact point for this topic: Arts et Métiers

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Advisor 3: AMMAR Amine amine.ammar@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: Vibration modes in nanostructures present a major interest in characterization of the materials properties. In particular, virus is known to resonate in the confined-acoustic dipolar mode with microwave of the same frequency. Indeed, investigating the vibrational modes of viruses has been motivated by the possibility of using ultrasonic waves to destroy or to inactivate a virus present in a living organism. The vibration of a free homogeneous and isotropic sphere was studied by Lamb using the theory of elastic media. However the free sphere model used to interpret the experimental results is a rough approximation of the actual environmental conditions of nanoparticles. A more general theory based on nonlocal elasticity for accurately predicting the vibration modes of nanosphere embedded in a viscoelastic media is the subject of this thesis. Several constitutive laws of the viscoelastic medium must be considered in order to obtain a more realistic model.

Required background of the student: Master Mechanics, Physics, Mathematics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Le Pommellec and El Baroudi. Correlation between the toroidal modes of an elastic sphere and the viscosity of liquids, Comptes Rendus Mécanique (2021).
2. Billon and El Baroudi. Mathematical Modelling of Love waves propagation in viscoelastic waveguide loaded with complex fluids, Applied Mathematical Modelling (2021).
3. El Baroudi. A note on the spheroidal modes vibration of an elastic sphere in linear viscoelastic fluid, Physics Letters A (2020)
4. El Jirari, El Baroudi and Ammar. Numerical investigation of the dynamical behavior of a fluid-filled microparticle suspended in human arteriole, Journal of Biomechanical Engineering (2021).
5. Yang, El Baroudi and Le Pommellec. Analytical approach for predicting vibration characteristics of an embedded elastic sphere in complex fluid, Archive of Applied Mechanics (2020).

Illustrations :

TITLE:A DECISION AID SYSTEM BASED ON A DECENTRALIZED ARCHITECTURE TO FASTER THE MANAGEMENT OF HAZARDS OCCURRING UNDER PRODUCTION AND LOGISTICS SYSTEMS

Topic number : ***2021_068***

Field : Information and Communication Science and Technology

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LISPEN - Laboratoire d'ingénierie des systèmes physiques et numériques
Lab location: Lille
Lab website:https://lispen.ensam.eu/

Contact point for this topic: Arts et Métiers

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Advisor 3: Roucoules Lionel lionel.roucoules@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: In the context of to the Industry 4.0, production and logistics systems are becoming more and more connected which help to monitor the industrial processes in order to detect hazards and then react rapidly to manage them. The problematic we would like to address is how to manage information system continuity linking the factory, its suppliers, the resources (robots or human). Second, we aim to imply some work on the decentralized information system that presents different advantages when managing planning, scheduling, resources assignment, reaction to hazards. It should answer to how to deal with a missing operator, or with a lack of raw material? How to propagate the impact of this hazard into the scheduling or assignment which was supposed to be done on the current day. Different applications are available on our lab (Lille and Aix-en-Provence) so it would be the opportunity to implement on real case study the development of such decision aid system.

Required background of the student: Industrial engineering, Information system, operational research

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Amzil K., Yahia E., Klement N., Roucoules L. (2021) Causality Learning Approach for Supervision in the Context of Industry 4.0. In: Roucoules L., Paredes M., Eynard B., Morer Camo P., Rizzi C. (eds) Advances on Mechanics, Design Engineering and Manufacturing III. JCM 2020. Lecture Notes in Mechanical Engineering. Springer, Cham. https://doi.org/10.1007/978-3-030-70566-4_50
2. Beauville dit Eynaud, A., Klement, N., Roucoules, L. et al. Framework for the design and evaluation of a reconfigurable production system based on movable robot integration. Int J Adv Manuf Technol (2021). https://doi.org/10.1007/s00170-021-08030-1
3. Derigent, W., Cardin, O. & Trentesaux, D. Industry 4.0: contributions of holonic manufacturing control architectures and future challenges. J Intell Manuf 32, 1797–1818 (2021). https://doi.org/10.1007/s10845-020-01532-x
4. Beauville dit Eynaud A., K. N. (2020). Risk and decision analysis for Reconfigurable Assembly System Design under uncertainties. 13th International Conference on Modeling, Optimization and Simuation-MOSIM'20-November 12-14, 2020 Agadir-Morocco" New advances and challenges for sustainable and smart industries".
5.

Illustrations :

illustration_2 ligne_pdf

TITLE:DEVELOPMENT OF ADVANCED MULTISCALE COMPUTATIONAL TOOLS FOR THE MULTIPHYSICS PREDICTION OF CARBON NANOTUBES (CNTS) FUZZY FIBER COMPOSITES

Topic number : ***2021_073***

Field : Material science, Mechanics and Fluids

Subfield: Mechanical engineering, Computational mechanics, Mechanics of Materials

ParisTech School: Arts et Métiers
Research team:
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.univ-lorraine.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: Chatzigeorgiou George georges.chatzigeorgiou@ensam.eu
Advisor 2: Meraghni Fodil fodil.meraghni@ensam.eu
Advisor 3: BENAARBIA Adil adil.benaarbia@ensam.eu
Advisor 4:

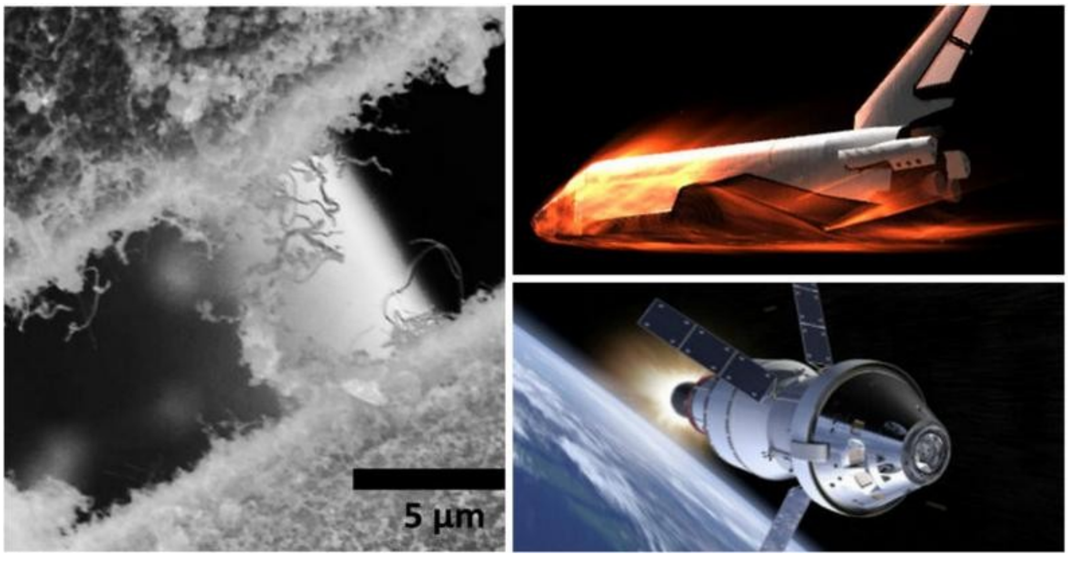
Short description of possible research topics for a PhD: Modern engineering applications require the development of composite materials with advanced mechanical, thermal, electrical etc. properties that provide high performances when employed for structural components. Carbon nanotubes (CNTs) have shown excellent characteristics when introduced in composite structures. A relatively new type of material system considers matrices reinforced with “fuzzy fibers” (fibers with CNTs grown on their surfaces). SiC fibers with grown CNTs are embedded in ceramic matrices towards developing lightweigt high-heat engine parts in aerospace applications . These complicated heterogeneous materials cannot be studied with the classical multiscale methodologies and they require appropriate micromechanics tools .
The proposed Ph.D. is going to investigate and design computational homogenization strategies (both full-field and mean-field) for composite structures reinforced with fuzzy fibers. The examined multiphysical properties will include mechanical, thermal and electrical properties as well as their coupling. Nonlinear and damage mechanisms will also been taken into account.

Required background of the student: Mechanical engineering, Computational mechanics, Mechanics of Materials

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. A.H.C. Hart, R. Koizumi, J. Hamel et al. (2017), “Velcro-Inspired SiC Fuzzy Fibers for Aerospace Applications”, ACS Applied Materials & Interfaces, Vol. 9(15), pp. 13742–13750.
2. G. Chatzigeorgiou, F. Meraghni, N. Charalambakis, A. Benaarbia (2020), “Multiscale modeling accounting for inelastic mechanisms of fuzzy fiber composites with straight or wavy carbon nanotubes”, International Journal of Solids and Structures, Vol. 202, pp. 39–57.
3. Q. Chen, G. Chatzigeorgiou, F. Meraghni (2021), “Hybrid hierarchical homogenization theory for unidirectional CNTs-coated fuzzy fiber composites undergoing inelastic deformations”,
Composites Science and Technilogy, Vol. 215, pp. 109012.
4.
5.

Illustrations :



TITLE:LEARNING WITH IMMERSIVE TECHNOLOGIES

Topic number : ***2021_074***

Field : Information and Communication Science and Technology

Subfield:

ParisTech School: Arts et Métiers
Research team:Presence & innovation http://lampa.ensam.eu/equipe-p-i-132195.kjsp?RH=1415871394252&RF=1478611858411
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location: Angers
Lab website:http://lampa.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: RICHIR SIMON simon.richir@ensam.eu
Advisor 2: Gorisse Geoffrey geoffrey.gorisse@ensam.eu
Advisor 3: Fleury Sylvain sylvain.fleury@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: The proposed research project aims at investigating the potential of immersive technologies (virtual reality, augmented reality) to learn technical and/or scientific contents. Virtual and augmented reality have developed rapidly over the last twenty years, both in terms of hardware and software quality, which offers several potentialities and use cases. However, these technologies remain under-exploited in several fields. The digital learning transformation, particularly in higher education and professional training, requires further investigations in order to adapt to the cognitive characteristics of learners and to develop pedagogical approaches that integrate these technologies in a relevant way.
Today, the main obstacles to the use of immersive technologies for learning are not only technical, but also ergonomics and pedagogical. It is necessary to identify the conditions of effectiveness of these devices by working on a better understanding of users' cognitive functioning in learning situations. More specifically, we want to study how virtual agents (autonomous characters controlled by the computer) can be used to facilitate learning. For instance, we could investigate how a virtual agent acting as a tutor could facilitate the learning of a technical procedure.

We could also study how to "capture" a teacher's lesson and how to reproduce it in a virtual environment, through a virtual agent (using the "CAPLAB" platform being installed in Laval).
In this context, experiments could be carried out to identify the optimal characteristics of this virtual tutor, in terms of realism, attractiveness and behavior, in order to enhance learners’ motivation. Evaluations could focus on learning performance (memorization, understanding, ability to reproduce the task in realistic context), participant involvement, but also on learners’ satisfaction in order to guarantee the acceptability of the technologies used in such contexts.
The use of artificial intelligence modules could be considered if this subject interests the selected candidate for the thesis.
This work will lead to high-level international publications that will shed light on relevant pedagogical tools and good practices for learning using immersive technologies.

Required background of the student: Master’s degree in computer science with extended knowledge of virtual reality. We are looking for a candidate with an interest in multidisciplinary research, at the frontier of virtual reality and experimental psychology. A strong interest for experimental research is required: production of protocols, conducting experiments, data analysis and writing. Applicants are expected to read, speak and write academic english.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Buttussi, F., & Chittaro, L. (2017). Effects of different types of virtual reality display on presence and learning in a safety training scenario. IEEE transactions on visualization and computer graphics, 24(2), 1063-1076.
2. Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. Journal of Computers in Education, 8(1), 1-32.
3. Hew, K. F., & Cheung, W. S. (2010). Use of three-dimensional (3-D) immersive virtual worlds in K-12 and higher education settings: A review of the research. British journal of educational technology, 41(1), 33-55.
4. Makransky, G., Andreasen, N. K., Baceviciute, S., & Mayer, R. E. (2020). Immersive virtual reality increases liking but not learning with a science simulation and generative learning strategies promote learning in immersive virtual reality. Journal of Educational Psychology.

5. Parong, J., & Mayer, R. E. (2018). Learning science in immersive virtual reality. Journal of Educational Psychology, 110(6), 785.

Illustrations :

TITLE:ANALYSIS, MODELING AND SIMULATION OF PARAMETRIC RESONANCES OF PIEZOELECTRIC STRUCTURES. APPLICATION TO NANO-SYSTEMS AND ENERGY HARVESTING

Topic number : ***2021_075***

Field : Information and Communication Science and Technology, Material science, Mechanics and Fluids, Mathematics and their applications

Subfield: Nonlinear Dynamics, Intelligent Systems, Micro/Nano Electromechanical Syetems

ParisTech School: Arts et Métiers
Research team:Olivier THOMAS group https://lispen.ensam.eu/user/87
Research lab: LISPEN - Laboratoire d'ingénierie des systèmes physiques et numériques
Lab location: Lille
Lab website:https://lispen.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: THOMAS Olivier olivier.thomas@ensam.eu
Advisor 2: GIRAUD-AUDINE Christophe christophe.giraud-audine@ensam.eu
Advisor 3: BENACCHIO Simon simon.benacchio@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: With the developments of sensors networks and the internet of things, the problem of powering such autonomous or dormant systems becomes critical and avoiding the use of batteries could be interesting. Therefore, ongoing researches focus on ambient energy conversion
thanks to phenomena such as photoelectricity, thermoelectricity or piezoelectricity. The latter conversion offers the possibility to harvest energy from vibrations and also becomes a widely used technique in the field of micro and nano electromechanical systems (M/NEMS), to replace traditional electrostatic transduction. For both energy harvesting and M/NEMS applications, parametric resonances can enhance
the performance of the system. A parametric driving of a resonant system is observed if the external forcing is equivalent to the periodic modulation of a system's parameter, its stiffness for instance. In this context, this PhD proposal aims at solving some open scientific and technological

questions, in the field of numerical simulation of those nonlinear structural systems as well as on the use of the properties of parametric resonances. In particular, it aims at:
(1) produce and exploit pertinent structural models able to predict parametric resonances in a structure, coming from either a mechanical action or a piezoelectric action. Numerical models using the finite-element methods will be at the core of the process;
(2) use those models to optimize piezoelectric resonators;
(3) design an electronic circuit able to enhance as much as possible the performance of a parametric harvester, in particular with switch strategies or power electronics techniques
This work will be based on theory (nonlinear oscillations, structural mechanics), numerical simulations (finite-elements, matlab) and experimental tests with up to date devices (scanning laser vibrometer, shaking table).

Required background of the student: Mechanical engineering, finite-element simulations, engineering vibrations, electronics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. O. Thomas, F. Mathieu, W. Mansfield, C. Huang, S. Trolier-McKinstry, and L. Nicu. Efficient parametric amplification in micro-resonators with integrated piezoelectric actuation and sensing capabilities. Applied Physics Letters, 102(16) :163504, 2013.
2. V. Denis, M. Jossic, C. Giraud-Audine, B. Chomette, A. Renault, and O. Thomas. Identification of nonlinear modes using phase-locked-loop experimental continuation and normal form. Mechanical Systems and Signal Processing, 106 :430–452, 2018.
3. A. Givois, C. Giraud-Audine, J.-F. Deü, and O. Thomas. Experimental analysis of nonlinear resonances in piezoelectric plates with geometric nonlinearities. Nonlinear Dynamics, 102 :1451–1462, 2020. 10.1007/s11071-020-05997-6.
4. A. Givois, J.-F. Deü, and O. Thomas. Dynamics of piezoelectric structures with geometric nonlinearities : A non intrusive reduced order modelling strategy. Computers & Structures, 253 :106575, 2021
5. M. Berardengo, O. Thomas, C. Giraud-Audine, and S. Manzoni. Improved resistive shunt by means of negative capacitance : new circuit,

performances and multi-mode control. Smart Materials and Structures, 25(7) :075033, 2016.

Illustrations :

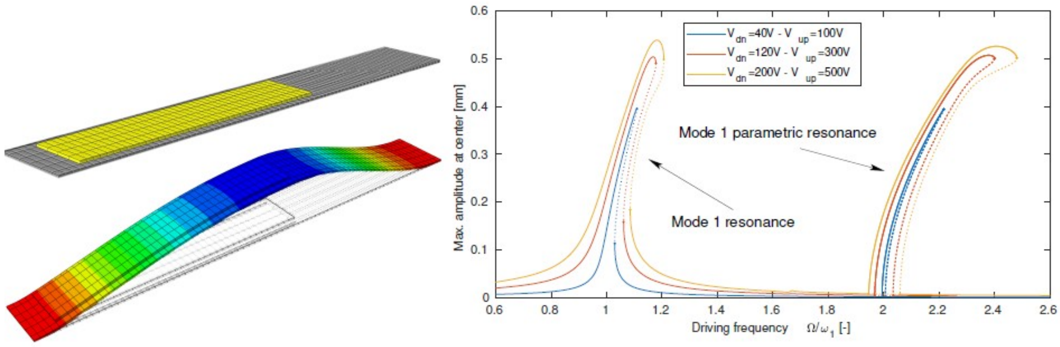
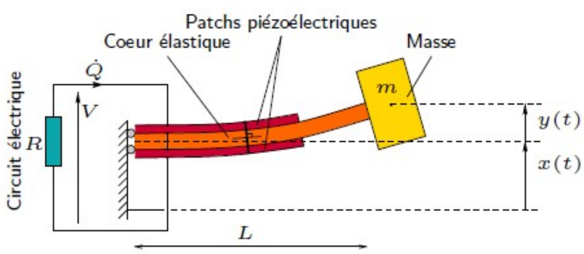
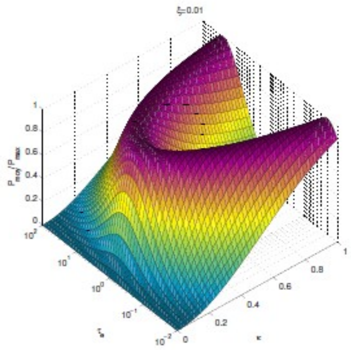
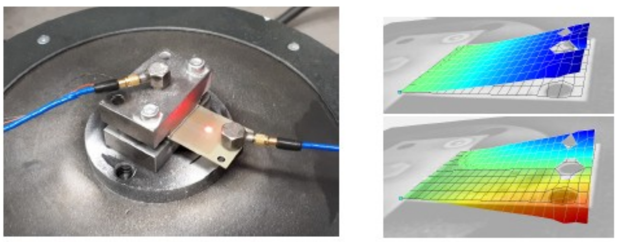


FIG. 1 – *Piezoelectric laminated structure in bending subjected to piezoelectric actuation*

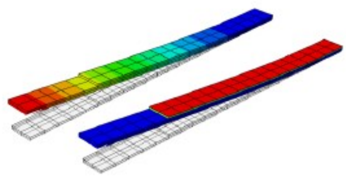




Surface d'optimisation



Tests vibratoires



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TITLE:MULTI-SCALE DATA-DRIVEN MODELLING OF SHORT-FIBRE REINFORCED COMPOSITES FOR AUTOMOTIVE APPLICATIONS

Topic number : ***2021_076***

Field : Material science, Mechanics and Fluids, Mathematics and their applications

Subfield:

ParisTech School: Arts et Métiers
Research team:SMART Research Group
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.fr

Contact point for this topic: Arts et Métiers

Advisor 1: Meraghni Fodil fodil.meraghni@ensam.eu
Advisor 2: PRAUD Francis francis.praud@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Short-fibre reinforced composites have shown to be among the best candidates to replace the actual metallic structural components in a view to reduce the mass of vehicles in the automotive industry. This is due to their remarkable properties induced by the association of stiff and tough glass fibre reinforcements with lightweight thermoplastic matrices. However, the use of such composites gives rise to highly complex mechanical responses that strongly depend on the fibre orientation, itself linked with the moulding process as fibres tends to be oriented along the moulding flow direction. Furthermore, the mechanical behaviour of these composites is also strongly influenced by the thermoplastic matrix, which exhibits both fluid and solid properties coupled to damage mechanisms . For these reasons, short-fibre reinforced composites have an anisotropic and time-dependent behaviour resulting from the microstructure arrangement, the complex rheological behaviour of the matrix and the fibre/matrix interface degradation mechanisms occurring at the scale of the microstructure.
Over the past years, many experimental and modelling efforts have been undertaken to better understand this type of composite. On the modelling

side, multi-scale modelling techniques either employing mean-field or full-field theories have been developed to predict the macroscopic response of these composites in relation with the local behaviour of the constituents and the arrangement of the microstructure. Although these approaches provided promising results in good agreement with experimental data, the significant computational cost and the important number of microstructural parameters hamper its practical use in structure analysis.
To overcome this limitation, the objective of the proposed PhD thesis is to investigate the use of data-driven modelling techniques such as non-intrusive PGD (Proper Generalized Decomposition) to efficiently deal with the simulations of short-fibre reinforced composites for which many microstructural parameters are involved. Indeed, PGD has been used in different multi-parametric problems involved in science and engineering fields, by assuming each parameter as an extra-coordinate of the model. Therefore, approximated responses of the composite can be determined by multi-dimensional regression using a precomputed dataset of offline solutions.

Required background of the student: Mechanical engineering, Mechanics of materials, Finite element method, Mathematics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. F. Praud, G. Chatzigeorgiou, J. Bikard and F. Meraghni, Phenomenological multimechanisms constitutive modelling for thermoplastic polymers, implicit implementation and experimental validation, Mechanics of Materials, 114:9–29, 2017.
2. M. Barral, G. Chatzigeorgiou, F. Meraghni, R. Léon, Homogenization using modified Mori-Tanaka and TFA framework for elastoplastic-viscoelastic-viscoplastic composites: Theory and numerical validation, International Journal of Plasticity, 127:102632, 2020.
3. Q. Chen, G. Chatzigeorgiou and F. Meraghni, Extended mean-field homogenization of viscoelastic-viscoplastic polymer composites undergoing hybrid progressive degradation induced by interface debonding and matrix ductile damage, International Journal of Solids and Structures, 210-211:91–17, 2021.
4. F. Praud, G. Chatzigeorgiou, and F. Meraghni, Fully integrated multi-scale modelling of damage and time-dependency in thermoplastic-based

woven composites, International Journal of Damage Mechanics, 30:163–195, 2021.
5. Tikkarouchine E., Benaarbia A., Chatzigeorgiou G., Meraghni F., (2020). Non-linear FE2 multiscale simulation of damage, micro and macroscopic strains in polyamide 66-woven composite structures: analysis and experimental validation. Composite Structures: 255: 112926.

Illustrations :

illustration illust_1_CSC

TITLE:EFFICIENT COMPUTATIONAL FRAMEWORK TO MODEL SIZE EFFECTS IN MINIATURIZED PRODUCTS

Topic number : ***2021_077***

Field : Material science, Mechanics and Fluids

Subfield: Computational mechanics, Nonlinear mechanics, Generalized continua

ParisTech School: Arts et Métiers
Research team:Méthodes Numériques, Instabilités et Vibrations (Numerical Methods, Instabilities and Vibrations)
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.fr

Contact point for this topic: Arts et Métiers

Advisor 1: ABED-MERAIM Farid Farid.Abed-Meraim@ensam.eu
Advisor 2: Jebahi Mohamed mohamed.jebahi@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Due to the increasing trend towards miniaturization, micro-scaled products have become widely used in various high technology fields, such as microelectronics and microbotics. However, when decreasing the geometrical size, several parameters, e.g., grain size and number of shallow grains, remain unchanged. This may result in modifying the mechanical properties of materials. As experimentally observed, in the size range between hundreds of nanometers and few tens of micrometers, the strength of materials is no longer scale-independent and the peculiar phenomenon “smaller is stronger” appears. Conventional plasticity theories cannot predict size-dependent behavior of materials, due to the lack of internal length scale(s). To overcome limitations of these theories, gradient-enhanced plasticity approaches have been proposed. These approaches, which are relatively recent, present very attractive features in capturing different kinds of size effects, making them one of the major scientific focuses of today. In this context, a flexible 2D gradient-based numerical tool has been developed in small and finite deformation frameworks. This tool has been successfully applied to study challenging size-dependent phenomena in ultra-thin sheet metals. The very interesting results obtained by this tool have motivated the present PhD project, which aims at developing an optimized 3D extension of this numerical tool. To achieve its objectives, this project is divided into three parts. First, an enhanced gradient-plasticity model will be developed, considering the recent progress made on the gradient-based description of size effects. Then, the proposed model will be implemented using accurate numerical techniques within the gradient-based numerical platform (COMAP) developed by the project team. Finally, the implemented model will be applied to study challenging small-scale problems, particularly formability of ultra-thin sheet metals. The project developments will offer to the scientific and industrial communities an original and powerful numerical tool that can be used for numerous breakthrough applications, like numerical optimization of the microstructure of miniaturized products. This has numerous economic, environmental, and social benefits in terms of design and fabrication of more effective industrial components.

Required background of the student: - Solid background in non-linear solid mechanics and finite element formulation and simulation;
- Good analytical and programming skills (e.g., Fortran, C, C++);
- Excellent English level

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Jebahi M., Cai L., Abed-Meraim F. (2020). Strain gradient crystal plasticity model based on generalized non-quadratic defect energy and uncoupled dissipation. International Journal of Plasticity, 126:102617. DOI: https://doi.org/10.1016/j.ijplas.2019.10.005.
2. Cai L., Jebahi M., Abed-Meraim F. (2021). Strain localization modes within single crystals using finite deformation strain gradient crystal plasticity. Crystals, in Press. DOI: https://doi.org/10.3390/cryst1010000.
3. Jebahi M., Forest S. (2021). Scalar-based strain gradient plasticity theory to model size-dependent kinematic hardening effects. Continuum Mechanics and Thermodynamics. DOI: https://doi.org/10.1007/s00161-020-00967-0.
4. Jedidi M. Y., Ben Bettaieb M., Abed-Meraim F. , Khabou M. T., Bouguecha A., Haddar M. (2020). Prediction of necking in HCP sheet metals using a two-surface plasticity model. International Journal of Plasticity, 128 :102641

5. Ben Bettaieb M. Abed-Meraim F. (2021). Formability prediction of substrate-supported metal layers using a non-associated plastic flow rule. Journal of Materials Processing Technology, 287:116694

Illustrations :

TITLE:GRAPH-BASED UNBOUNDED CONSTRAINED MODELS SEARCH FOR HIGH-LEVEL LOGICAL REASONING

Topic number : ***2021_080***

Field : Information and Communication Science and Technology, Mathematics and their applications

Subfield: Computer science, combinatorial algorithms, constraint programming, finite model search, graph theory, cyber-physical systems engineering.

ParisTech School: Arts et Métiers
Research team:
Research lab: LISPEN - Laboratoire d'ingénierie des systèmes physiques et numériques
Lab location: Aix-en-Provence
Lab website:lispen.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: Pernot Jean-Philippe Jean-Philippe.Pernot@ensam.eu
Advisor 2: Kleiner Mathias mathias.kleiner@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The project is a fundamental research proposal involving algorithms and software

development. The project aims at providing an original reasoning approach for hard
combinatorial problems based on the generation of finite graphs under a set of
structural constraints.
More precisely, we are interested in problems where knowledge is represented in the
form of an object-oriented model with additional constraints expressed in first-order
predicate logic (for instance, metamodels conforming to OMG's MOF and their
associated OCL constraints). In this context, a classical problem is to be able to
generate an instance of the object model which satisfies all the

constraints. For instance, it can be used to automatically explore cyber-physical systems engineering alternatives given a loosely defined partial solution.

Existing approaches mostly rely on the mapping between the model and its constraints to a lower-level constraint programming paradigm (e.g. SAT, CSP) where resolution (e.g. constraint-based solving) is achieved. However the translations induce drawbacks such as the loss of structure knowledge about the problem, they require to bound the solutions potential number of elements (since real first-order logic is rarely supported by current solvers), and some constraints are hard (or even impossible) to translate efficiently.

The main idea behind this project is that resolution at a graph-level, using graph generation techniques, may allow for a more efficient resolution. Indeed it is then possible to exploit the structure of the object-model and its solutions to guide the search more efficiently (for instance graph-based heuristics), discard unsatisfiable partial solutions that could not be detected otherwise (for instance graph

isomorphisms), and it is not necessary to bound the number of solution elements (by generating structures of a priori unknown size). On a more practical level, another benefit of the approach is that it reduces the gap between the original knowledge representation and the reasoner paradigms, hence allowing for a more integrated use of the solver in a software chain (e.g. reverse mapping of the solution, understandable structure-based explanations, etc.). Advances in the theoretical aspects, novel algorithms, usecases and integration of a free software library in a model-based software environment (such as Eclipse Modelling Framework) are among the expected outputs of the project.

The proposed approach will be validated on multiple case studies ranging from litterature toy problems to more complex applications (cyber-physical systems engineering, 3D geometry, natural language parsing and texts generation, etc.)

Required background of the student: Computer science, excellent programming skills, combinatorial algorithms,
constraint programming.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Laurent Hénocque, Mathias Kleiner, Nicolas Prcovic, "Advances in polytime isomorph elimination for con-
figuration", Principles and Practice of Constraint Programming-CP 2005, p. 301-313, Springer, 2005.
2. Mathias Kleiner, Marcos Didonet Del Fabro, "A generic approach to model generation operations", Journal of
Systems and Software, p 136-155, Elsevier, 2018.
3. Hu H., Kleiner M., Pernot J-P., "Over-constraints detection and resolution in geometric equation systems",
Computer-Aided Design (2017), vol. 90, pp. 84-94.
4. Gilles Gouaty, Lincong Fang, Dominique Michelucci, Marc Daniel, Jean-Philippe Pernot, Romain Raffin, San-
drine Lanquetin, Marc Neveu, "Variational geometric modeling with black box constraints and DAGs", Com-
puter-Aided Design 75, p. 1-12, 2016
5.

Illustrations :

TITLE:PHYSICALLY INFORMED AND DATA-DRIVEN APPROACHES TOWARDS RELIABLE SIMULATION OF THERMOPLASTIC COMPOSITE AUTOMOTIVE COMPONENTS

Topic number : ***2021_081***

Field : Design, Industrialization, Material science, Mechanics and Fluids

Subfield: Mechanical engineering, Computational mechanics, Mechanics of Materials.

ParisTech School: Arts et Métiers
Research team:Mécanique des Matériaux, des Structures et du Vivant (MMSV) / Milieux Multiphasés et couplages multiphysiques
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.univ-lorraine.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: BENAARBIA Adil adil.benaarbia@ensam.eu
Advisor 2: MERAGHNI Fodil fodil.meraghni@ensam.eu
Advisor 3: NACHTANE Mourad mourad.nachtane@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: In the industry, the challenge of confronting the structural behaviour of lab tests and real structures with a thorough understanding calls for further improvement regarding the scientific tools required for the interpretation and implementation of the material behavior within commercial simulation software. Whatever the scale of description chosen, the quality and validity of simulation results naturally depend on the relevance of the behaviour equations chosen to account for the physics. The phenomenological nature of these constitutive equations generally introduces modelling errors, leading to mismatches between simulations and experimental results. The main objective of this PhD project is to propose alternative ways to overcome this limitation by merging classical simulation tools with data coming from experimental measures in a dynamic way. Several numerical algorithms, based on parameter identification and data-driven techniques, will be designed throughout the project in order to strengthen the link between data and computational mechanics, notably for automotive applications, through a holistic approach based on digital twin concept (simulation environments in which the designed composite properties can virtually be tested without the need for costly and time-expensive physical mock-ups). This will be coupled with Model Order Reduction techniques to overcome the computation costs and achieve computations at the real time.

Required background of the student: Applicants should have, or expect to achieve at least a Master's degree (or an equivalent overseas degree) in Mechanical Engineering. Candidates with suitable experience in computational mechanics and/or data-driven programming are welcome to apply.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Benaarbia A., Chrysochoos A. (2017). Proper orthogonal decomposition application for estimating heat sources within thermoplastic composite materials. Quantitative Infrared Thermography Journal, 14: 132-152.
2. Benaarbia A., Chatzigeorgiou G., Kiefer B., Meraghni F., (2019). A fully coupled thermo-viscoelastic-viscoplastic-damage framework to study the cyclic variability of the Taylor-Quinney coefficient for semi-crystalline polymers. International Journal of Mechanical Sciences 163: 105128.
3. Tikkarouchine E., Benaarbia A., Chatzigeorgiou G., Meraghni F., (2020). Non-linear FE2 multiscale simulation of damage, micro and macroscopic strains in polyamide 66-woven composite structures: analysis and experimental validation. Composite Structures: 255: 112926.
4.
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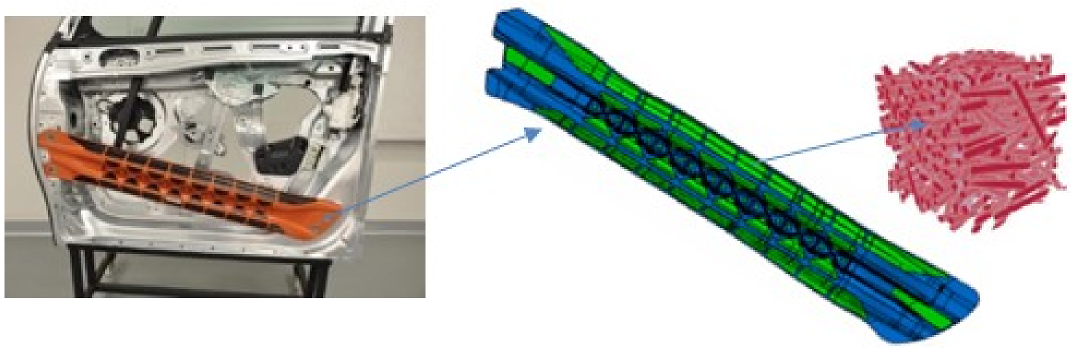
Illustrations :



TITLE:SUSTAINABILITY ASSESSMENT AND MULTI-PHYSICAL/MULTI-SCALE MODELLING OF SURFACE INTEGRITY IN MACHINING OF INCONEL 718 SUPERALLOY USING ADVANCED CUTTING TOOLS MATERIALS

Topic number : ***2021_082***

Field : Material science, Mechanics and Fluids

Subfield: Mechanical Engineering, Manufacturing Processes

ParisTech School: Arts et Métiers
Research team:High Speed Machining
Research lab: LABOMAP - Laboratoire Bourguignon des matériaux et procédés
Lab location: Cluny
Lab website:http://labomap.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Outeiro José jose.outeiro@ensam.eu
Advisor 2: Birembaux Hélène helene.birembaux@ensam.eu
Advisor 3: Besnard Aurélien aurelien.besnard@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: The machining industry is constantly looking for new solutions to increase the productivity and the quality of products, but also to reduce the environmental footprint and cost of the process. Today, cemented carbides are the most used cutting tool material in the industry. In 2017, the worldwide production of cemented carbide exceeded 90,000 tons, being about 65% used by the machining industry. There is a need to reduce the among of carbide materials used in the cutting tool and replace them by other high performance tool materials, such as PCBN and PCD materials.
The project is focused on the sustainable machining of Inconel 718, a superalloy largely used in the aerospace industry, using advanced tool materials and environmentally friendly metalworking fluids (MWF). The objective is to investigate and optimize the turning operation of Inconel 718 alloy using ceramic and PCBN cutting tools, and environmentally friendly MWF like liquid CO_2, for and enhanced surface integrity of aerospace components made on Inconel 718. To reach this objective multi-physical/multi-scale modelling and experimental approaches will be applied. A sustainability assessment will be conducted considering the

results obtained by these advanced tool materials and those obtained using traditional cemented carbide tools.

Required background of the student: We are looking for a highly motivated candidate with a Master’s degree in Mechanical Engineering or Materials Science. A knowledge of manufacturing processes, continuum mechanics and finite element method will be considered a strong merit.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. R. M’Saoubi, T. Larsson, J.C. Outeiro, Y. Guo, S. Suslov, C. Saldana, S. Chandrasekar, “Surface integrity analysis of machined Inconel 718 over multiple length scales”, CIRP Annals - Manufacturing Technology, Vol. 61/1, pp. 99-102, 2012.
2. X. Xu, J.C. Outeiro, J. Zhang, B. Xu, W. Zhao, “Machining simulation of Ti6Al4V using coupled Eulerian-Lagrangian approach and a constitutive model considering the state of stress”, Simulation Modelling Practice and Theory, Vol. 110, pp. 102312, 2021.
3. I. Hamm, G. Poulachon, F. Rossi, H. Birembaux. Innovative experimental measurements of cutting temperature and thermal partition during Ti-6Al-4V orthogonal cutting. Procedia CIRP, volume 102, 2021, p. 281-286.
4. X. Xu, Jun Zhang, J.C. Outeiro, B. Xu, W. Zhao, Multiscale simulation of grain refinement induced by dynamic recrystallization of Ti6Al4V alloy during high speed machining, Journal of Materials Processing Technology, Vol. 286, pp. 116834.
5. J. C. Outeiro, J. C. Pina, R. M’Saoubi, F. Pusavec, I. S. Jawahir, “Analysis of Residual Stresses Induced by Dry Turning of Difficult-to-machine Materials”, CIRP Annals - Manufacturing Technology, Vol. 57, pp. 77–80, 2008.

Illustrations :

TITLE:DESIGN A SAFE WORK-CELL FOR HUMAN-ROBOT CO-ACTIVITY IN INDUSTRY

Topic number : ***2021_085***

Field : Design, Industrialization

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: RAHARIJAONA Thibaut thibaut.raharijaona@univ-lorraine.fr
Advisor 2: WU Yier yier.wu@ensam.eu
Advisor 3: SAVIN Jonathan jonathan.savin@inrs.fr
Advisor 4:

Short description of possible research topics for a PhD:
Collaboration between a human operator and a robot is a key feature of the “industry of the future”. The increasing interactions between humans and robots raise questions in terms of occupational risk prevention. For instance, how can we ensure, at the earliest stage of a work-cell design, that protective devices are properly chosen and placed at the appropriate safety distances? Conventional design methods rely on the “worst-case hypothesis” given by the robot manufacturer to implement safety equipment and strategies. These methods often lead to over-evaluation of the safety criteria, typically an overestimated breaking distance, which drastically reduces the system performance.
We need to know how to combine robot performance and human safety in a cobotic cell. The thesis aims at: (i) Identifying the potential hazardous zones according to the manufacturing task (robot trajectory, external loading, etc), in order to optimize the placements of safety equipment. (ii) Developing the perception of the human presence in the shared work-cell by sensor implementation (eg. with a depth camera and/or distance sensors), and adapting the robot’s control strategy accordingly. (iii) Developing the human operator perception by using an augmented reality of the work-cell in order to distinguish the safe and dangerous working area in real-time. The overall aim of the thesis is to develop real-time

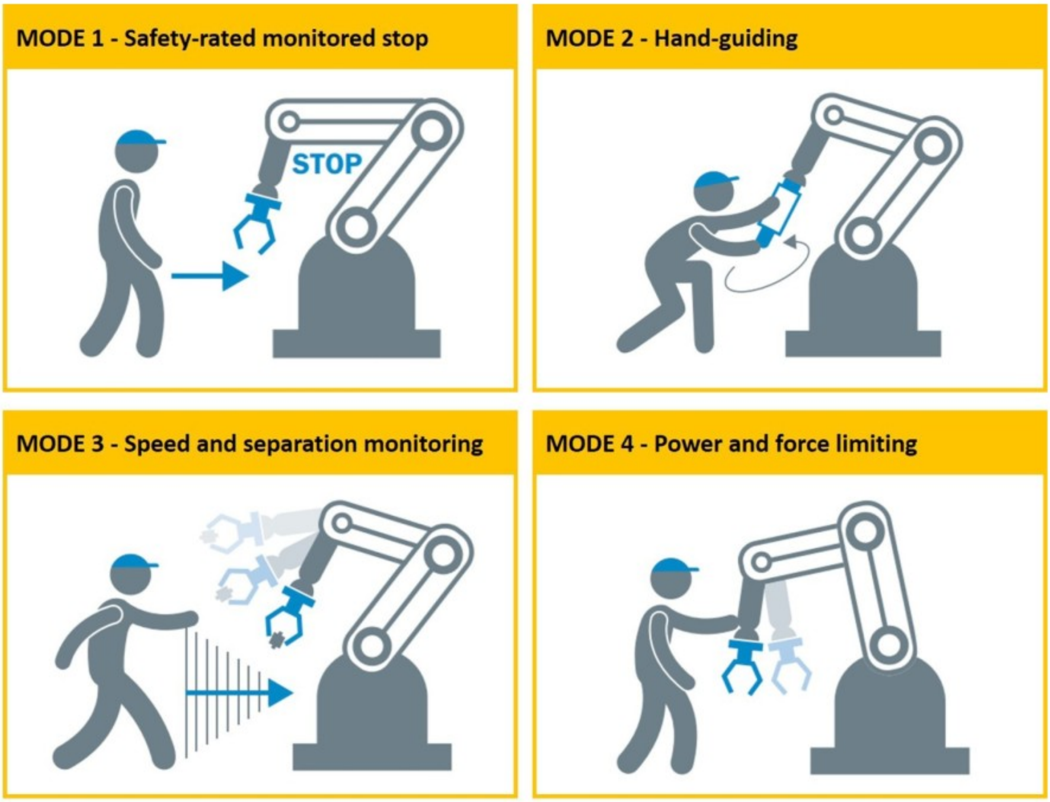
robot simulation and control according to human presence in the work-cell via sensor data fusion technologies. We will validate the design method on robots working in a real industrial scenario.

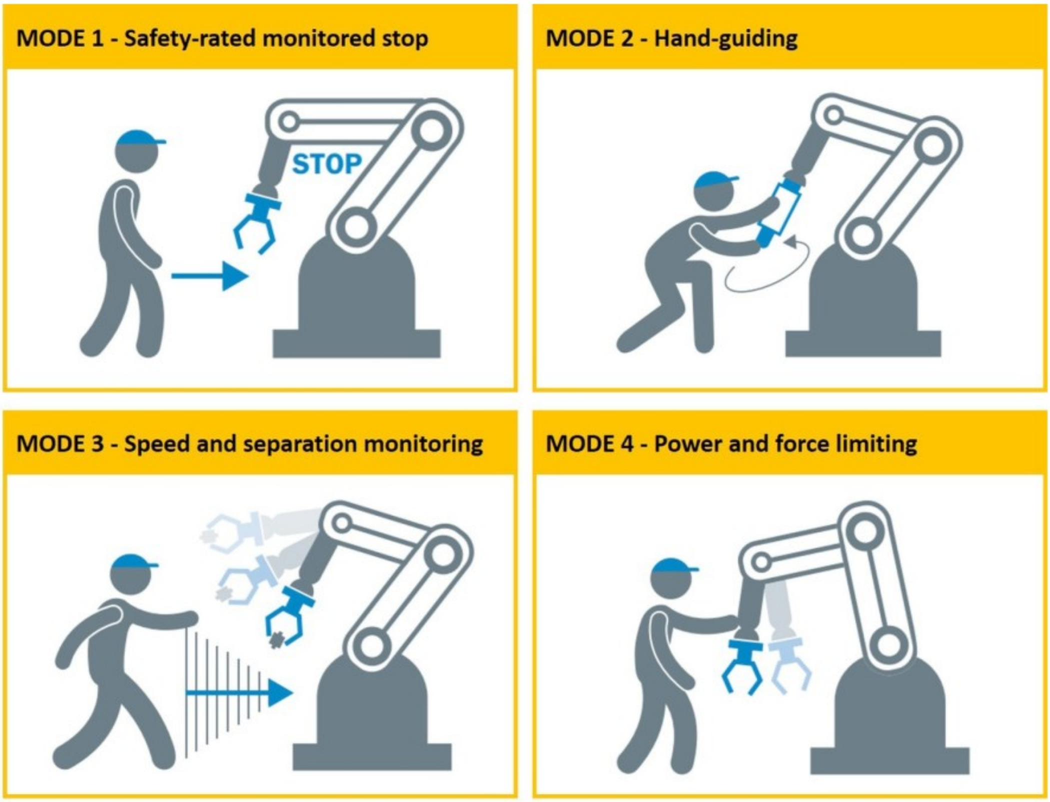
Required background of the student: Robotic modeling and control, Sensor implementation, Data fusion

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. J. Savin, J. Baudoin, J.P. Bello and Y. Wu, “Dynamic simulation of the stopping performance of an industrial robot for the design of a safe work-cell”, 10th international conference on safety of industrial automated systems, 2021.
2. P. Martin, B. Daille-Lefèvre, J. Marsot, X. Godot, G. Abba, A. Siadat, and M. Gomez-Echeverri. “New Issues for Workers Safety in the Factory of the Future.” In Advances on Mechanics, Design Engineering and Manufacturing II, 402–411, 2019.
3. B. Tahar-Hakim, M. Bounouar, R. Bearee, and A. Siadat. “Industry of the Future, Future of Work: The Case of Collaborative Robotics.” In Proceedings of the 21st Congress of the International Ergonomics Association (IEA 2021), 29–35, 2021.
4.
5.

Illustrations :


MODE 1 - Safety-rated monitored stop
STOP
MODE 2 - Hand-guiding
MODE 3 - Speed and separation monitoring
MODE 4 - Power and force limiting


MODE 1 - Safety-rated monitored stop
STOP
MODE 2 - Hand-guiding
MODE 3 - Speed and separation monitoring
MODE 4 - Power and force limiting

TITLE:INTELLIGENT VISUAL ANALYTICS FOR THE DESIGN AND MONITORING OF TURBO ENGINE SYSTEMS

Topic number* : *2021_086

Field : Design, Industrialization, Information and Communication Science and Technology, Material science, Mechanics and Fluids

Subfield: Intelligent Design and monitoring of Sustainable Systems

ParisTech School: Arts et Métiers
Research team:Turbomachines
https://lifse.artsetmetiers.fr/equipes/turbomachines
Research lab: LIFSE - Laboratoire Ingénierie des Fluides Systèmes Energétiques
Lab location: Paris
Lab website:https://lifse.artsetmetiers.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: GARBAYA Samir samir.garbaya@ensam.eu
Advisor 2: KHELLADI Sofiane sofiane.khelladi@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD:
Turbomachines are complex machines with components that could fail or develop faults when operating. These problems could be difficult to handle and can have an impact on other components in the case of failure. The prediction of the machine states and the remaining useful life (RUL) in real time mode are important objectives. This could allow reducing maintenance costs and the stock of spare parts. The main objective of this PhD thesis is to develop innovative methodologies of visual analytics and machine learning to support the design and monitoring of the functioning of turbo engine systems. Real-time monitoring and data capture such as noise/vibration, energy consumption, heat/temperature, pressure, wear, etc. are necessary to extract the knowledge to optimize the machine design at the virtual prototyping stage and take proactive actions to prevent the machine failure during the operation of the physical systems.

Required background of the student: Applicants must have completed a Master of Engineering in a discipline related to mechanical engineering. Prospective applicants must have skills in Computational fluid dynamics, Experimental fluid dynamics and Turbomachines, Machine learning, Sensor technologies and Real-time data capture and analysis.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Maryam Boumrah, Samir Garbaya and Amina RADGUI, "Real-Time Visual Analytics for Patient's Health Monitoring", Visualization of Information and Scientific data, Visu 2021, 8 June 2021, (https://journee-visu.github.io/2021/documents/boumrah.pdf)
2. Garbaya, S., Romano, D. and Hattar, G. (2019), "Gamification of assembly planning in virtual environment", Assembly Automation, Vol. 39 No. 5, pp. 931-943. https://doi.org/10.1108/AA-10-2018-0147
3. Samir Garbaya and Vincent Hugel, "Modelling Movement Time for Haptic-enabled Virtual Assembly", the International Conference on Human Computer Interaction Theory and Applications (HUCAPP), 27-29 February 2020, Valletta, Malta
4. OUZANI R., Khelladi S., Danlos A., (2020) Mixing in turbulent compressible heated coaxial jets: a numerical study - International Journal of Hydrogen Energy, Vol.45, Issue 33, pp. 16816-16837, 2020. https://doi.org/10.1016/j.ijhydene.2020.01.194
5. H. Vanaei, M. Deligant, K. Raissi, S. Khelladi, A. Tcharkhtchi, (2020) Influence of process parameters on thermal and mechanical properties of PLA fabricated by Fused Filament Fabrication - Polymer Engineering and Science

Illustrations :

TITLE:IDENTIFICATION OF PARAMETERS CONTROL AND IMPROVEMENT FROM THIXOFORGING PROCESS OF ALUMINUMS (VS STEEL)

Topic number : ***2021_094***

Field : Design, Industrialization, Material science, Mechanics and Fluids

Subfield: New Forming Process and Processus Eng., and material Eng,

ParisTech School: Arts et Métiers
Research team:Forming Process department
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: BIGOT Régis regis.bigot@ensam.eu
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD:
Thixoforging is a manufacturing process of metal alloys at semisolid state. Semisolid state is obtained by heating the material from the solid state, up to a temperature within the solidus-liquidus temperature range. Since always, Industry minimizes manufacturing process plan and increases mechanical behaviour. In this topic, the thixoforging process offers important perspectives. It is on the way of industrial development between casting and forging process thanks the typical rheological behaviour of the semisolid material.
This research work must contribute to improve comprehension of the aluminium behaviour during thixoforging and define the application field for this process. To achieve this goal, experimental testing with device will must be use and develop. The main thixoforging parameters to shape these alloys will be identify and study such as the forming speed, the initial steel temperature, the initial tool temperature, etc. The quality of the thixoforged parts must be study and characterize by the macrographic and micrographic observations of their metallurgical structure and mechanical tests or with other means that will be choice. The tests can be compared with simulations in order to determine and improve the predictive model capacity implemented.

Required background of the student: The student must be have preferably a background in forming process, steel or aluminum material and perhaps eng. Software Catia®, Forge® or Abaqus®. Knowledge of metallurgy may also be a plus. He need have a good approach with experimental studies and numerical simulation. The use of numerical inverse models to improve the simulation models can be useful.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Aba-perea, P., Becker, E., Recherche, I. De, Matériaux, T., Procédés, M., & Metz, F. F.-. (2020). Measurement and modeling of thermal evolution during induction heating and thixoforming of low carbon steel. Journal of Materials Processing Tech., 283(April), 116717. https://doi.org/10.1016/j.jmatprotec.2020.116717

•

2. Becker, E., Bigot, R., Rivoirard, S., Faverolle, P. (2017). EXPERIMENTAL INVESTIGATION OF THE THIXOFORGING OF TUBES OF LOW-CARBON STEEL. Journal of Materials Processing Technology, 1 Oct 2017, PROTEC15423

3. Balan, T., Becker, E., Langlois, L., & Bigot, R. (2017). CIRP Annals - Manufacturing Technology A new route for semi-solid steel forging. CIRP Annals - Manufacturing Technology, 66(1), 297–300. https://doi.org/10.1016/j.cirp.2017.04.111

4. Gu, G., Pesci, R., Langlois, L., Becker, E., Bigot, R., & Guo, M. X. (2014). Microstructure observation and quantification of the liquid fraction of M2 steel grade in the semi-solid state, combining confocal laser scanning microscopy and X-ray microtomography. Acta Materialia, 66, 118–131. https://doi.org/10.1016/j.actamat.2013.11.075

5. Gu, Guochao, Pesci, R., Langlois, L., Becker, E., & Bigot, R. (2015). Microstructure investigation and flow behavior during thixoextrusion of M2 steel grade. Journal of Materials Processing Technology, 216, 178–187. https://doi.org/10.1016/j.jmatprotec.2014.09.009

Illustrations :

illustration Poster E BECKER Thixo

TITLE:CONSEQUENCES OF CLIMATE CHANGE ON THE STRUCTURAL INTEGRITY OF BURIED LARGE-DIAMETER WATER-TRANSMISSION MAINS

Topic number : ***2021_095***

Field : Environment Science and Technology, Sustainable Development, Geosciences, Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: I2M - Institut de Mécanique et d'ingénierie
Lab location: Bordeaux
Lab website:https://www.i2m.u-bordeaux.fr

Contact point for this topic: Arts et Métiers

Advisor 1: YANEZ GODOY Humberto humberto.yanez-godoy@u-bordeaux.fr
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Les stratégies de gestion des systèmes d'eau potable, notamment les conduites de transport d'eau potable de grand diamètre, sont basées généralement sur l'avis d'experts. Parmi ces stratégies quelques unes sont difficilement formalisées et ne répondent que partiellement aux priorités. En effet, les cinétiques de dégradation pour ce type des conduites sont mal connues et les modèles numériques de prédiction des dégradations sont rarement disponibles. En outre, les effets du changement climatique dans des zones à fort stress hydrique doivent être mieux maitrisés. En effet, s'ils sont plus ou moins connus sur les sols qui reçoivent ces conduites, peu de lien est fait dans les études avec l'impact sur les ouvrages eux mêmes. Ces aspects sont de nature à compliquer de plus en plus la gestion des priorités des actifs hydrauliques. Les variations dimensionnelles provoquées par les grands cycles d'hydratation-séchage et leurs répercussions en terme de gonflement ou de retrait peuvent induire la rupture des ouvrages par des tassements différentiels en particulier. Ce travail devrait nous amener à l'acquisition d'une meilleure connaissance des grands déterminants du comportement mécanique des conduites principales d'alimentation en eau par une meilleure connexion entre l’étude sur le sol et l’impact généré sur ces structures. Ce projet de thèse a pour but de développer un modèle géomécanique-fiabiliste pour étudier le comportement des conduites d’eau potable sous contraintes qui dépendent fortement des conséquences du changement climatique. Ce modèle permettrait d’envisager la construction d’outils dédiés à la gestion de la maintenance des systèmes d’eau potable dans des régions à fort stress hydrique.

Required background of the student: Civil engineering

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Yáñez-Godoy H., Elachachi S.M., Darwich G. “Geomechanical behaviour of large diameter pressure water pipelines in unidimensional heterogeneous soils”. Safety, Reliability, Risk, Resilience and Sustainability of Structures and Infrastructure: Proceedings of the 12th International Conference on Structural Safety and Reliability (ICOSSAR2017), Vienna, Austria, 6-10 August 2017. Christian Bucher, Bruce R. Ellingwood, Dan M. Frangopol (Ed.): TU Verlag, ISBN: 978-3-903024-28-1, pp. 386-395, 2017.
2. Yáñez-Godoy H, Elachachi S-M, Chesneau O, Feliers C. Identification of key determinants of geo-mechanical behavior of an instrumented buried pipe. In: Proceedings of the 13th International Conference on Applications of Statistics and Probability in Civil Engineering (ICASP13). Korean Institute of Bridge and Structural Engineers; 2019. p. 1297-304.
3. Yanez-Godoy H, Darwich G, Elachachi SM, Chesneau O, Feliers C. Suivi du comportement mécanique d’une conduite d’eau potable enterrée et instrumentée : analyse des premières mesures. Acad J Civ Eng. 2018;36(1):629–32.
4.
5.

Illustrations :

TITLE:PHASE FIELD MODELING OF DAMAGE AND FRACTURE IN POLYCRYSTALLINE MATERIALS UNDER THERMOMECHANICAL LOADING

Topic number : ***2021_098***

Field : Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:DIPPE
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location: Angers
Lab website:http://lampa.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Ammar Amine amine.ammar@ensam.eu
Advisor 2: EL AREM Saber saber.elarem@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: In the present work, we are interested in the development of a model which is

dedicated to the description of damage in polycrystalline metallic materials. This
study aims at building a model that would describe how cracks initiate,

propagate and interact with each other at the micro-scale.
To reach this objective, it is proposed to use the phase field method (PFM)
within the context of polycrystalline plasticity. Indeed, within the framework of
irreversible thermodynamics, the phase-field method has proved to be extremely
powerful in the description of microstructural transformations without having to
track the evolution of individual interfaces, as in the case of sharp interface
models. In the present case, it is expected that the introduction of an order

parameter associated with damage will allow for capturing some complex

phenomena like crack kinking or crack branching.
The proposed study would therefore consists of:
(1) Defining an appropriate set of internal variables (and the associated energy
potential) to deal with both elasticity, plasticity and damage in crystalline

materials at the micro-scale
(2) Deriving the evolution equations associated with the different internal

variables within the context of the phase field method
(3) Implementing the constitutive equations within an appropriate numerical
solver (finite element solver for instance)
(4) Validating the proposed formulation by testing its ability to reproduce some
known experimental results.
At the end of this PhD research program, the numerical model will allow for
investigating the interactions between various physical mechanisms governing
the macroscopic behavior (e.g. plasticity, damage) at different length scales.

Required background of the student: Solid Mechanics, numerical mechanics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Gmati,H. "Phase field modelling of fracture of elastic and elastoviscoplastic solid materials", Thèse de doctorat ENSAM, 2020

2. Gmati, H, Mareau, C, Ammar, A, El Arem, S. A phase-field model for brittle fracture of anisotropic materials. Int J Numer Methods Eng. 2020; 121: 3362– 3381. https://doi.org/10.1002/nme.6361

3. H. Gmati C. Mareau,S. El Arem, A. Ammar. « Phase field modeling of damage and fracture inp olycristalline materials », MECAMAT, Aussois, France,2019

4. C. Mareau, « A non-local damage model for the fatigue behaviour of metallic
polycrystals», Philo. Mag., 100(8), 955-981, 2020
5.

Illustrations :

TITLE:NONLINEAR DYNAMICS OF CRACKED STRUCTURES: APLICATION TO WIND TURBINES

Topic number : ***2021_100***

Field : Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:DIPPE
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location: Angers
Lab website:lampa.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: Ammar Amine amine.ammar@ensam.eu
Advisor 2: EL AREM saber saber.elarem@ensam.eu
Advisor 3: EL Baroudi Adil adil.elbaroudi@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: For rotating shafts, a propagating fatigue crack can have detrimental effects on the reliability of a steam, gas or wind turbines where these vital parts are subjected to very arduous working conditions in harsh environment. The vibration analysis and modeling of the shaft and cracks are necessary for a reliable identification of the crack location and depth to avoid catastrophic failures. In fact, cracks can develop and propagate to relevant depths without affecting consistently the normal operating conditions of the shaft. We recently have presented a systematic approach in dealing with the problem of modeling cracked rotating shafts. The breathing mechanism identification is the crucial step in the process and has been made with the greatest care. The approach presented is original and its implementation in industrial context is straight forward. The objective, based on previous development we have

recently proposed, is to apply our approach to develop a new and systematic
methodology combining finite elements (1D and 3D) and modal analysis to analyzing the nonlinear dynamics of wind turbines.
We will be focusing on the effect of the cracks presence on the behaviour of the turbine to develop tools for early online crack detection.

suggest an analysis methodology.

Required background of the student: solid mechanics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. S. El Arem. On the mechanics of beams and shafts with cracks : A standard and generic approach. Eur Jou Mechanics-A/Solids 85,104088, 2020
2. S. El Arem. Nonlinear analysis, instability and routes to chaos of a cracked rotating shaft. Nonlinear Dynamics , 96(1) :667-683, 2019
3. S. El Arem and M. Ben Zid. On a systematic approach for cracked rotating shaft study : breathing mechanism, dynamics and instability. Nonlinear Dynamics , 88(3) :2123-2138, 2017
4. S. El Arem and Q.S. Nguyen. Nonlinear dynamics of a rotating shaft with a breathing crack. Annals of Solid and Structural Mechanics , 3(1-2) :1-14, 2012
5. S. El Arem and H. Maitournam. A cracked beam finite element for rotating shaft dynamics and stability analysis. J. of Mechanics of Materials and Structures , 3(5) :893-910, 2008

Illustrations :

TITLE:MODELING OF THE FLUID-SOLID INTERACTIONS DURING STEADY AND TRANSIENT FLOWS OF NON-NEWTONIAN FLUIDS THROUGH DEFORMABLE POROUS MEDIA

Topic number : ***2021_101***

Field : Chemistry, Physical chemistry and Chemical Engineering, Energy, Processes, Environment Science and Technology, Sustainable Development, Geosciences, Life and Health Science and Technology , Material science, Mechanics and Fluids

Subfield: Transfer in porous media

ParisTech School: Arts et Métiers
Research team:Porous Media team
https://www.i2m.u-bordeaux.fr/Recherche/TREFLE-Transfert-Fluide-Energetique
Research lab: I2M - Institut de Mécanique et d'ingénierie
Lab location: Bordeaux
Lab website:https://www.i2m.u-bordeaux.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: Ahmadi-Senichault Azita azita.ahmadi@ensam.eu
Advisor 2: Rodriguez de Castro Antonio
antonio.rodriguezdecastro@ensam.eu
Advisor 3: Omari Abdelaziz Abdelaziz.Omari@enscbp.fr
Advisor 4:

Short description of possible research topics for a PhD: The mechanical interactions between non-Newtonian fluids and deformable porous media are at the interface between fluid physics and solid mechanics, and are of interest in many applications, including health and materials fields. For example, the flow of blood throughout the entire vascular network of arteries, veins and vessels of varying sizes plays a key role in the functioning human body by supplying our cells with oxygen and nutrients. A partial or total blockage (thrombus) in this vascular network due to an atheroma deposit consisting of cholesterol and cellular debris on the walls of the arteries can lead to atherosclerosis and heart attack or to a stroke. A detailed understanding of blood flow both at the local level and at the level of the capillary network is therefore essential for the development of preventive and therapeutic strategies. Moreover, blood is a shear-thinning complex fluid, which exhibits non-Newtonian rheology. Its unsteady circulation through the vascular tree is pulsatile. This situation therefore raises the question of how to accurately represent the interactions between a complex fluid and a deformable capillary. In the field of material sciences, improving our knowledge of physical phenomena occurring during the processing of fiber-reinforced polymer composite is equally crucial in order to produce optimized structural or functional components. In particular, understanding the flow of the liquid polymer through the fibrous reinforcements requires still further research. The objective of this PhD thesis is to develop a macroscopic model for the flow of a shear-thinning fluid through a deformable porous medium by using pore network modelling methods. The accuracy of the model will be assessed through cutting-edge laboratory experiments and numerical simulations.

Required background of the student: Fluid and solid mechanics, numerical simulations, experimental skills, spoken and written English or French

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Kirst, C., Skriabine, S., Vieites-Prado, A., Topilko, T., Bertin, P., Gerschenfeld, G., Verny, F., Topilko, P., Michalski, N., Tessier-Lavigne, M., Renier, N (2020). Mapping the Fine-Scale Organization and Plasticity of the Brain Vasculature. Cell 180, 780–795
2. Peyrounette, M., Davit, Y., Quintard, M., Lorthois, S. (2018). Multiscale modelling of blood flow in cerebral microcirculation: Details at capillary scale control accuracy at the level of the cortex. PLoS One 13(1), e0189474.
3. Rodríguez de Castro, A., Goyeau, B. (2021). A pore network modelling approach to investigate the interplay between local and Darcy viscosities during the flow of shear-thinning fluids in porous media. Journal of Colloid and Interface Science 590, 446 – 457.
4. Rodríguez de Castro, A., Agnaou, M., Ahmadi-Sénichault, A., Omari, A., Numerical investigation of Herschel-Bulkley fluid flows in 2D porous media: yielding behaviour and tortuosity, Computers and Chemical Engineering, Volume 140, 2 September 2020, 106922.
5. Weibel, E. R. (2009). What makes a good lung? Review article. Swiss Medical Weekly 139(27–28), 375–386.

Illustrations :

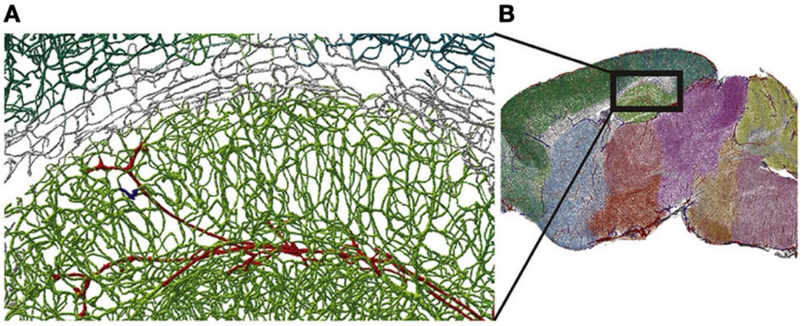


Figure 1. *Multiscale architecture of microvascular networks in a mouse brain obtained by light sheet microscope. (A) Microscopic scale of interconnected capillaries. (B) Macroscopic scale where the network of capillaries can be represented by a continuous equivalent medium. (Adapted from Kirst et al. 2020)*

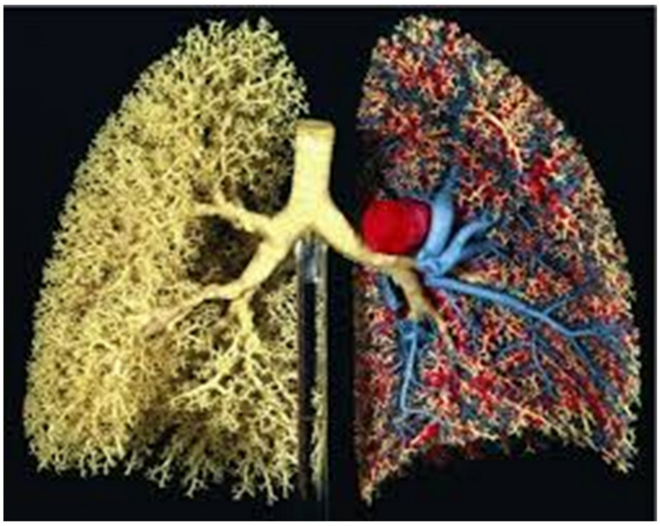


Figure 2. *Resin cast of the human respiratory tree showing the dyadic branching of the bronchi from the trachea and the systematic reduction in the diameter and length of the airways with progressive branching. In the left lung, pulmonary arteries (red) and veins (blue) are also represented (Weibel 2009).*

TITLE:MULTI-SCALE APPROACH FOR THE DEVELOPMENT OF EFFECTIVE SOIL REMEDIATION METHODS BASED ON FOAM INJECTION

Topic number : ***2021_102***

Field : Chemistry, Physical chemistry and Chemical Engineering, Energy, Processes, Environment Science and Technology, Sustainable Development, Geosciences, Material science, Mechanics and Fluids

Subfield: Transfer in porous media

ParisTech School: Arts et Métiers
Research team:Porous Media team
https://www.i2m.u-bordeaux.fr/Recherche/TREFLE-Transfert-Fluide-Energetique
Research lab: I2M - Institut de Mécanique et d'ingénierie
Lab location: Bordeaux
Lab website:https://www.i2m.u-bordeaux.fr

Contact point for this topic: Arts et Métiers

Advisor 1: Ahmadi-Senichault Azita azita.ahmadi@ensam.eu
Advisor 2: Rodriguez de Castro Antonio
antonio.rodriguezdecastro@ensam.eu
Advisor 3: Omari Abdelaziz Abdelaziz.Omari@enscbp.fr
Advisor 4:

Short description of possible research topics for a PhD:
Hydrocarbon spills can seep through the unsaturated zone of aquifers due to gravity and capillary forces, polluting water from the phreatic zone and the areas covered during their passage. Since most hydrocarbons are toxic and carcinogenic, the clean-up of these sites is a major challenge. Unlike site remediation processes by excavation, "in situ" treatments have the major advantage of not requiring soil movement. However, injecting a displacing fluid into heterogeneous or fracture-containing polluted soil generates preferential flow, leading to low sweeping efficiency. The use of foams has proven to be a relevant solution to overcome this problem. This method consists in saturating the high permeability area with foam, which produces a significant pressure loss by viscous dissipation and diverts the flow to less permeable regions, thereby improving the rate of pollutant recovery. In addition, the ability of foams to effectively invade the less permeable strata of heterogeneous makes them suitable as mobility control agents. They can also be used to

convey clean-up products (such as phosphates or iron nanoparticles). Therefore, mastering the rheology of foams when injected in porous media is essential to design an effective clean-up strategy. In this PhD thesis, multi-scale numerical and experimental approaches will be combined to relate process conditions to the efficacy of the soil remediation technique. This will allow for the optimization of pollutant recovery. In particular, the choice of the surfactant will be addressed, and microfluidic experiments will be carried out to assess the mechanisms of stability and coalescence in the presence and absence of the polluting phase.

Required background of the student: Fluid mechanics, numerical simulation, experimental skills, knowledge of physical chemistry would be appreciated

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. EPA. “Monitored natural attenuation of petroleum hydrocarbons. U.S. EPA Remedial Technology Fact Sheet, EPA/600/F-98/021”, May 1999.

2. Forey, N., Atteia, O., Omari, A., Bertin, H. (2021). Use of saponin foam reinforced with colloidal particles as an application to soil remediation: Experiments in a 2D tank. Journal of Contaminant Hydrology 238. 103761

3. Hernando, L., Satken, B., Omari, A., Bertin, H. (2018). Transport of polymer stabilized foams in porous media: Associative polymer versus PAM. Journal of Petroleum Science and Engineering 169, 602 – 609.

4. Omirbekov, S., Davarzani, H., Colombano, S., Ahmadi-Senichault, A. (2020). Experimental and numerical upscaling of foam flow in highly permeable porous media. Advances in Water Resources 146, 103761

5. Shojaei, M. J., Rodríguez de Castro, A., Méheust, Y., Shokri, N. (2019). Dynamics of foam flow in a rock fracture: Effects of aperture variation on apparent shear viscosity and bubble morphology, Journal of Colloid and Interface Science 552, 464 – 475.

Illustrations :

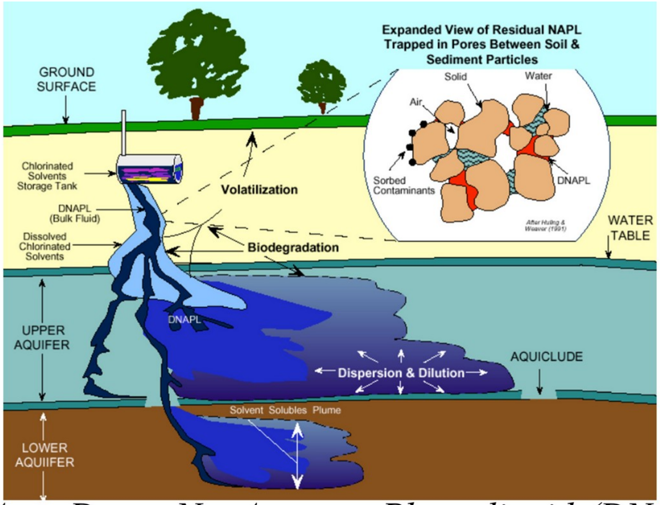


Figure 1. *As a Dense NonAqueous Phase liquid (DNAPL) moves through the subsurface, some of the liquid may be trapped in the soil or sediment pores (residual saturation); some may evaporate (volatilization); some may become sorbed to the surface of the soil particles (sorption) and some may dissolve in the ground water (dissolved plume). Since DNAPL are denser than water, they will move down the aquifer until they become trapped in the less permeable layers.*

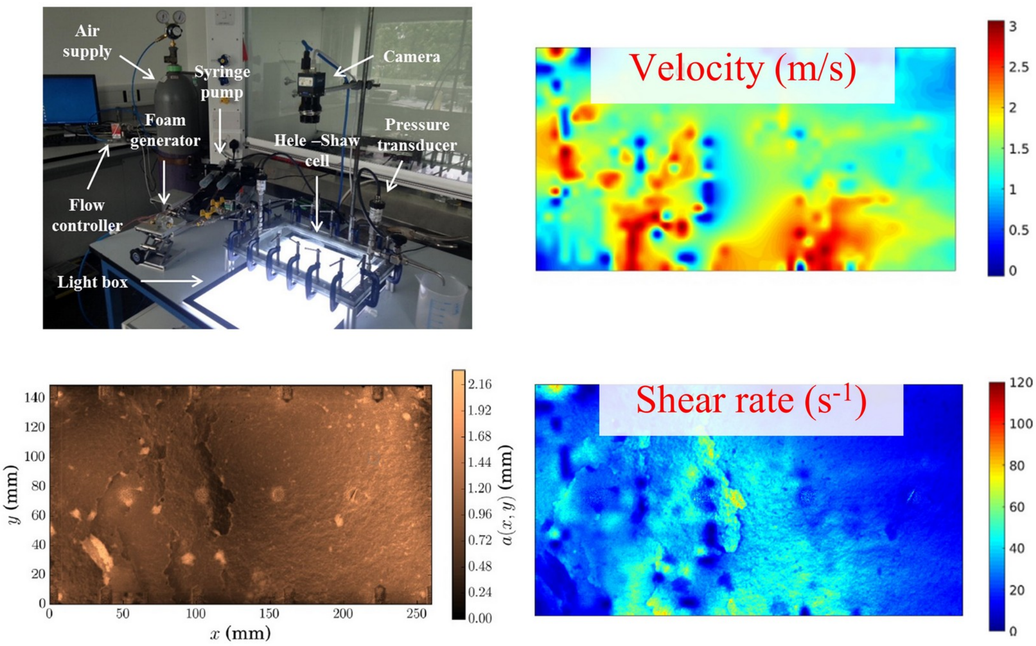


Figure 2. *(a) Experimental setup used to inject pre-generated foam through a replica of a rough-walled rock fracture. (b) aperture map (c) Velocity map obtained by PIV. (d) Shear-rate map. From Shojaei et al. (2019)*

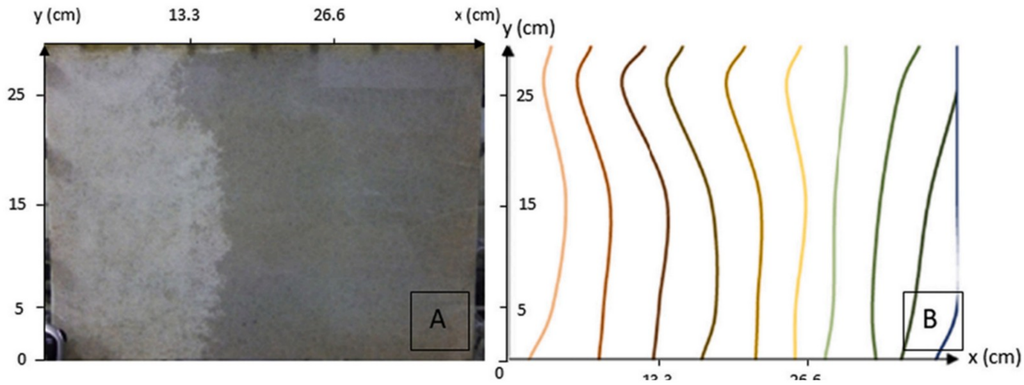


Figure 3 (A) Injection of a dyed foam (in white) through a 2D tank filled with sand and saturated with surfactant. (B) Subsequent positions of the invasion front. From Forey et al. (2021).

TITLE:MODELING OF THE WOOD BEHAVIOR UNDER SEVERE LOADING CONDITIONS: CASE OF THE VENEER CUTTING BY ROTARY PEELING PROCESS

Topic number : ***2021_106***

Field : Design, Industrialization, Energy, Processes, Environment Science and Technology, Sustainable Development, Geosciences, Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:Wood sciences, Wood peeling, wood grading
http://labomap.ensam.eu/wood-material-and-machining-100680.kjsp?RH=1415278881726&RF=1415535985117
Research lab: LABOMAP - Laboratoire Bourguignon des matériaux et procédés
Lab location: Cluny
Lab website:http://labomap.ensam.eu/

Contact point for this topic: Arts et Métiers

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Advisor 2: Yaich Mariem mariem.yaich@ensam.eu
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Advisor 4:

Short description of possible research topics for a PhD: The wood material presents an interesting alternative to reduce the carbon impact of industry and construction, especially veneer industry according to the huge amount of design possibilities offered by this material. However, its use is still is limited in many applications because of its natural high variability. In order to encourage the use of local hardwood and fast-growing species, characterized by a high heterogeneity, the peeling process has been used for many decades for the construction of technical wood products (plywood, LVL, CLT…) with high mechanical properties . Contrary to other manufacturing processes, the guarantee of the good quality of the chip, which is the veneer in our case, is deeply required. This still is difficult to ensure due to either an inadequate definition of the machining conditions or an under comprehension of the material behavior. Despite the continuous efforts to experimentally determine the main reasons of the damage initiation and propagation within the machined veneer , the setting up of a reliable numerical modeling is deeply required. It aims to allow the access to local and instantaneous information, as well as to determine the effect of material property and process parameter on the veneer quality. This constitutes the main objective of this thesis subject, which will be focused initially on determining the effects of the machining conditions on the peeling process for homogeneous species. Comparisons between different plasticity criteria, rheology and damage models will be set up in the aim to determine the most accurate ones, which are able to adequately reproduce the wood behavior under several loading conditions. The material behavior under sever loading conditions, similar to those reached during the peeling process, will be studied. The thermomechanical contact conditions in the tool-veneer-pressure bare interfaces will be also investigated to study the effects of both hydrothermal wood preparation and cutting conditions. Afterword, more generalized material behavior will be defined to the numerical simulations. The proposed strategy aimed to establish a reliable modeling of peeling process, even in the case a highly heterogeneous material with pronounced variability and coupling material parameters. Comparisons between the computed cutting forces, veneer thickness and the experimental ones obtained from the instrumented industrial peeling line of the LaBoMaP will be performed to validate the numerical simulations. Attention will be paid to the distribution of numerical plastic strain, strain rate, stress and damage parameter in the veneer during and after the peeling process in order to determine the main reasons of the damage initiation and propagation. The main advantageous of the proposed study is summarized on its ability to consider the high variability of the wood and to separately determine the material and process parameters affecting the veneer quality, which remains impossible based only on an experimental approach.

Required background of the student: Mechanical engineering, Programming, Finite element modeling (A good knowledge of the wood material and its manufacturing will be appreciated)

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. R. Duriot, G. Pot, S. Girardon, L. Denaud (2021) New perspectives for LVL manufacturing from wood of heterogeneous quality – Part 2: Modeling and manufacturing of variable stiffness beams. Forests, 12 (9): 1275

2. Thibaut, B., and Beauchêne, J. (2004). Links between Wood Machining Phenomena and

Wood Mechanical Properties: The Case of 0°/90° Orthogonal Cutting of Green Wood.

3. S. Stefanowski, R. Frayssinhes, G. Pinkowski, L. Denaud (2020). Study on the in-process measurements of the surface roughness of Douglas fir green veneers with the use of laser profilometer. European Journal of Wood and Wood Products, 78 (3), 555-564
4. Thibaut, B., Denaud, L., Collet, R., Marchal, R., Beauchêne, J., Mothe, F., Méausoone, P.-J.,
Martin, P., Larricq, P., and Eyma, F. (2016). Wood machining with a focus on French
research in the last 50 years. Annals of Forest Science 73, 163–184
5.

Illustrations :

illustration peeling_modeling_labomap_2021_CSC