TIME TABLE

TIME	Monday May 9	Tuesday May 10	Wednesday May 11	Thursday May 12	Friday May 13
09.00 - 09.45	Registration	Dubar	Dubar	Ponthot	Montmitonnet
09.45 - 10.30	Montmitonnet	Dubar	Dubar	Ponthot	Montmitonnet
11.00 - 11.45	Bay	Montmitonnet	Ponthot	De Chiffre	Montmitonnet
11.45 - 12.30	Bay	Montmitonnet	Ponthot	De Chiffre	Bay
14.00 - 14.45	Bay	Bay	Montmitonnet	Bay	
14.45 - 15.30	De Chiffre	Bay	Montmitonnet	Bay	
16.00 - 16.45	Poster Session	Dubar	Ponthot	De Chiffre	
16.45 - 17.30	Poster Session	Dubar	Ponthot	Bay	
18.00	Welcome aperitif				

ADMISSION AND ACCOMMODATION

The course is offered in a hybrid format giving the possibility to attend the course also by remote (on Microsoft Teams platform). On-site places are limited and assigned on first come first served basis.
The registration fees are:

- On-site participation, 600.00 Euro + VAT*
This fee includes a complimentary bag, five fixed menu buffet lunches, hot beverages, downloadable lecture notes.
Deadline for on-site application is April 9, 2022.

- Online participation, 250.00 Euro + VAT*
This fee includes downloadable lecture notes.
Deadline for online application is April 27, 2022.

Application forms should be sent on-line through the following web site: http://www.cism.it
A message of confirmation will be sent to accepted participants.

Upon request a limited number of on-site participants can be accommodated at CISM Guest House at the price of 30 Euro per person/night (mail to: foresteria@cism.it).

* where applicable (bank charges are not included)
Italian VAT is 22%.

CANCELLATION POLICY

Applicants may cancel their registration and receive a full refund by notifying CISM Secretariat in writing (by email) no later than:
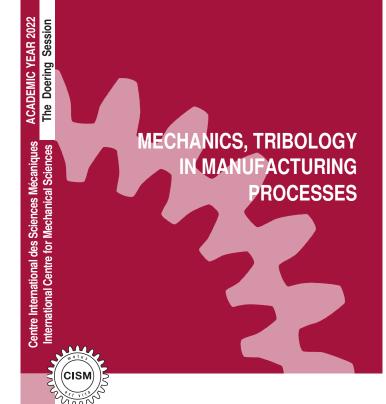- April 9, 2022 for on-site participants (no refund after the deadline);
- April 27, 2022 for online participants (no refund after the deadline).
Cancellation requests received after these deadlines will be charged a 50.00 Euro handling fee. Incorrect payments are subject to Euro 50,00 handling fee.

GRANTS

A limited number of participants from universities and research centres who are not supported by their own institutions can request the waive of the registration fee and/or free lodging.
Requests should be sent to CISM Secretariat by **March 9**, **2022** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

For further information please contact:
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MECHANICS, TRIBOLOGY IN MANUFACTURING PROCESSES

Advanced Professional Training coordinated by

Pierre Montmitonnet
MINES ParisTech-PSL
Sophia Antipolis, France

Niels Bay
Technical University of Denmark
Lyngby, Denmark

Udine *May 9 - 13* **2022**

MECHANICS, TRIBOLOGY IN MANUFACTURING PROCESSES

Tribology, the science of friction and wear between solids in contact, requires a multiscale modelling approach. On the one hand, friction and wear are systemic properties, i.e. not attached to a material but to a system. A tribosystem consists in a pair of solid bodies (their nature, manufacturing and surface finishing, shape...), the contact conditions (kinematics, loadings) and, critically, lubrication. On the other hand, surfaces are rough and this plays a major role through loading at asperity level and real area of contact. Tribology thus requires modelling at the macroscale – system scale – and at a microscale – typically the roughness scale, possibly going down to the atomic scale for the understanding of the fundamental interactions.

Manufacturing has a double interaction with tribology. Friction does govern a number of features of manufacturing processes: global forces and torques, machine power and strength requirement, material flow, tool deformation and machine vibrations (chatter) which impact product dimensions and quality, tool wear and surface quality of products... Reciprocally, manufacturing processes impart products with surface features (topography, composition, superficial properties, residual stresses...) which control their functionality.

Tribology in manufacturing is therefore a key engineering science subject. Chemistry is important for tribology (materials nature and properties, microstructural features, choice of lubricants); however tribology is strongly anchored in mechanics and generally taught in a Mechanical Engineering curriculum.

Numerical modelling has become a key tool in this field. Transmission of this know-how will be an integral part of the course:
- macroscopic process modelling discloses the working conditions of the interface;
- microscale numerical modelling gives precise, physics-based homogenized friction or wear models;
- FE2 approaches of mixed regime lubrication address multiple micro-mechanisms of lubrication.

These trends will be illustrated and their potential discussed in view of scientific knowledge as well as for practical application.

Through a multidisciplinary approach combining theory and practice, this course intends to provide its audience, academic researchers as well as R&D engineers from industry, with both the well-established bases of this particular field and advanced models and operational concepts illustrated by examples of recent and on-going research, including on how tribology may contribute to greener manufacturing.

The course is addressed, through its mixture of basic and advanced notions, to:
- MSc or doctoral students who can learn approaches useful for their thesis;
- young researchers completing their specialization in tribology of manufacturing;
- more experienced researchers in mechanical engineering or tribology who desire to enter this specific field;
- engineers from industry who want to add to their practical know-how an in-depth understanding of the underlying mechanisms.

In a poster session at the end of the first day, the attendants will be given an opportunity to present one of their research subjects through a brief pitch and a poster, to be discussed with other participants and with the experts.

An attestation describing the content will be provided to students on demand in view of ECTS accountance, to be determined with their administration.

PRELIMINARY SUGGESTED READINGS

J.A. Schey: Tribology in Metalworking: friction, lubrication and wear. ASM (Metals Park, USA) 1983.

C.V. Nielsen, N. Bay: Review of friction modelling in metal forming processes. J. Mat. Process. Tech. 255 (2018) 234-241.

N. Bay: Cold Welding 1 - Characteristics, bonding mechanisms, bond strength. Metal Construction 18, 6 (1986) 369-372.

N. Bay, A. Azushima, P. Groche, I. Ishibashi, M. Merklein, H. Morishita, T. Nakamura, S. Schmid, M. Yoshida:

Environmentally Benign Tribo-systems for Metal Forming, Keynote paper, CIRP Annals – Manufacturing Technology, 59, 2 (2010) 760-780.

N. Bay, D.D. Olsson, J.L. Andreasen: Lubricant Test Methods for Sheet Metal Forming. Tribology Int. 41, 9 (2008) 844-853.

Y. Carretta, R. Boman, J.I. Bech, N. Legrand, M. Laugier, J.-P. Ponthot: Numerical modelling of microscopic lubricant flow in sheet metal forming. Application to plane strip drawing. Int. J. Numer. Meth. Engg 112, 3 (2017) 203-237.

P. Montmitonnet Plasto-Hydrodynamic Lubrication – application of lubrication theory to metal forming processes. C.R. Acad Sci. Paris IV, 2, 5 (July 2001) 729-737.

P. Montmitonnet, E. Felder: A Third-Body Modelling Strategy for the Prediction of Adhesive Transfer Layer Formation on Forming Tools. Proc. ICTMP 2016 (Phuket, Thailand, 29 Feb – 2 March 2016), Thai Tribology Association, 2016, 62-73.

L. De Chiffre, H. Kunzmann, G.N. Peggs, D.A. Lucca: Surfaces in Precision Engineering, Microengineering and Nanotechnology. CIRP Annals 52, 2 (2003) 561-577.

D.A. Axinte, W. Belluco, L. De Chiffre: Reliable tool life measurements in turning - an application to cutting fluid efficiency evaluation. Int. J. Mach. Tools Manuf 41, 7 (2001) 1003-1014.

M. Dubar, A. Dubois, L. Dubar: Wear analysis of tools in cold forging: PVD versus CVD TiN coatings. Wear 259 (2005) 1109-1116.

LECTURERS

Bay Niels - Technical University of Denmark, Lyngby, Denmark
9 lectures on:
Application of the plasticity theory to roughness-scale modeling of friction; Practice, physical mechanisms and modelling of welding by plastic deformation; Methodology and applications of process-adapted tribotest development; Environmentally friendly lubricants in metal forming.

De Chiffre Leonardo - Technical University of Denmark, Lyngby, Denmark
4 lectures on:
Tribology of metal cutting processes: the impact of friction in cutting processes with the importance of fresh metal surface and heat generation; Metal cutting lubrication and its monitoring; Tribotesting in cutting processes.

Dubar Laurent - Université Polytechnique Hauts-de-France, Le Mont Houy, Valenciennes, France
6 lectures on:
Interaction between damage micro-mechanisms, wear and friction, wear phenomenology and wear mechanisms, different modes of material damage and their relation to wear modes, modelling of wear, wear consequences on superficial metal structure and properties, interactions between friction and wear.

Montmitonnet Pierre - MINES ParisTech-PSL, Sophia Antipolis, France
8 lectures on:
General notions necessary for the specialized lectures, i.e. modelling rough surfaces, adhesion physics and the modelling of seizure, modelling of material removal processes based on wear such as grinding or sawing, control of friction in metal forming through tool surface engineering and lubrication system optimization.

Ponthot Jean-Philippe - Université de Liège, Liège, Belgium
6 lectures on:
Numerical modelling of lubrication: hydrodynamic lubrication phenomenology and modelling using Reynolds equation, 2-scale modelling of mixed-to-boundary regime micromechanisms coupling asperity-scale plasticity models and fluid lubrication theory, and the particular case of micro-hydrodynamic lubrication.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from the CISM web site. Instructions will be sent to accepted participants.