

Colloquium Final Report

N. 602 – Composite manufacturing processes. Analyses, modelling and simulations

Dates and location: **13/03/2019 - 15/03/2019, Lyon, France**

Chairperson **Philippe Boisse**

Co-Chairperson **Stepan Lomov**

Conference fees

- Early Registration **390.0 €**
- Late Registration **440.0 €**

What other funding was obtained? **INSA Lyon (1500€)**

What were the participants offered? **What were the participants offered? The registration fees included:**

- **The book of abstracts.**
- **cocktail-dinner.**
- **2 daily coffee breaks and lunches.**
- **Gala dinner at Brasserie Georges, Lyon.**

Number of members of Euromech (reduced registration fee) **9**

Number of non-members of Euromech (full registration fee) **45**

Applicants (members)

- Abderrahmane Ayadi
- Valter Carvelli
- Emmanuel De Luycker
- Victor Eremeev
- Oussama Haji
- Vu Ngoc Khiêm
- Yordan Kyosev
- Stepan Lomov
- Julia Orlik

Applicants (non members)

- Thierry Antonini
- Omar BAHO
- Sylvain BEL

PRESIDENT

GertJan van Heijst
G.J.F.v.Heijst@tue.nl

VICE PRESIDENT

Patrick Huerre
huerre@ladhyx.polytechnique.fr

SECRETARY GENERAL

Pierre Suquet
Laboratoire de Mécanique et
d'Acoustique
4 Impasse Nikola Tesla CS 40006
13453 Marseille Cedex 13 –
France
suquet@lma.cnrs-mrs.fr

MANAGEMENT ADVISOR

Sara Guttilla
sara.guttilla@euromech.org

TREASURER

Stefanie Reese
euromech@ifam.rwth-aachen.de

- Lourens Blok
- Joël Bréard
- Francisco Chinesta
- David Colin
- Rita de Cassia Costa Dias
- Marco Valerio d'Agostino
- Cédric DESCAMPS
- Dominik Dörr
- Damien Durville
- Christian Garnier
- Sarah Gayot
- Thomas Gereke
- Juan Manuel González Cantero
- Benjamin Gröger
- Stephen Hallett
- Mathieu Imbert
- Yoshihiko Kanda
- Radmir Karamov
- Luise Kärger
- Redouane Lombarkia
- Angela MADEO
- TEIXEIRA Marie
- Arturo Mendoza Quispe
- Preetamkumar Mohite
- Lukas Münch
- Arbia NOUIGUES
- Laurent ORGEAS
- KRISHNA MOHAN P R
- Xiongqi Peng
- Christian Poppe
- Arjun Radhakrishnan
- Ulrich Sachs
- Vijay Sahadevan
- Rohit George Sebastian
- Adam Thompson
- Mark Turk
- Kristof Vanclooster
- Andrey Vasilyev
- peng wang
- Yanneck Wielhorski
- Shenglei XIAO
- Zhaofei Xiao

Scientific Report

Scientific report

Among the various lightweight materials, composites appear as very promising materials and their development have attracted more and more attention in the transportation. The aviation industry was the first to introduce composite materials to replace conventional materials such as aluminium. As an example, the amount of composite materials in airplane has raised to 53% in the Airbus A350. However, the properties of composite materials are not well reported because they are a complex class of materials exhibiting highly anisotropic behavior. They must be then fully characterized as it was done for conventional materials (e.g. aluminum, titanium ...). Moreover, it is obvious that the methods developed for metals are not applicable for the composites.

Composite materials are available in many form and produced using a variety of manufacturing processes. The manufacturing processes are essential for the quality of the final composite. These processes are numerous and often complex. Manufacturing simulation enables an initial validation of the process and the determination of suitable process parameters. This can prevent a time consuming and expensive "trial and error" process design. Furthermore, the fibre reorientation due to forming is predictable, which can be used as input value for structural analyses.

The simulation of composite manufacturing processes needs the knowledge, the experimental analysis, and the modelling of the physical phenomena involved. During the process, these phenomena and in particular the mechanics concern materials in large deformation (depending on temperature, phase change...). The experimental analysis, modelling and the simulation of physical phenomena during composite forming have been the objectives of the colloquium.

The conference have concern principally the composites with continuous fibres for structural parts and a large number of processes:

Thermoset and thermoplastic prepreg forming, LCM processes (Liquid Composite Moulding), RTM processes, infusion.

The proposed EUROMECH Colloquium 602 was an opportunity to establish a state of art and to exchange the different approaches aimed at tackling tough problems related to the mechanics of composites materials at various scales during manufacturing.

Topics of the Colloquium:

1. Draping of fibrous preforms and prepregs.

Forming of a continuous fiber reinforcements leads to specific mechanical problems because the mechanical behavior of these reinforcements is specific in view of the possible relative slippage between the fibers and because of the quasi-inextensibility of the fibers. The following topics have been discussed: Mechanical tests for fibrous reinforcements (in plane and transverse shear, biaxial tension, bending, transverse compaction, constitutive law for textile reinforcements (Hyper elasticity, hyper viscoelasticity...), Simulations of preform deformation at macro, meso and microscale, specific finite elements, locking of textile materials, full field strain measurements (DIC) and Micro CT analyses of internal geometry, generalized continuum mechanics for textile materials. Second gradient approaches

2. Thermo mechanics, Thermo kinetics and Couplings

Composite forming processes are generally carried out at high temperature and the coupling between mechanical and thermal temperature is important. The consolidation and crystallization of the resin are also coupled with the forming deformation. The following topics have been discussed: Multi-scale and multi-physical models and algorithms, Curing, crystallization, polymerization, Coupling algorithmic, Advanced calculation strategies in couplings (reduction of models, ...)

After the colloquium:

- A group of participants are in contact with the CISM International Centre for Mechanical Sciences (Udine), to offer a course on composite forming
- About twenty participants sent an extended version of their contribution to the journal Composites part A for publication in a virtual special issue on the subject of the colloquium

Number of participants from each country

France 18

Germany 11

UK 7
Belgium 3
Netherlands 1
Spain 1
Russia 2
India 2
China 1
Autriche 2
Italy 1

Applicants (members)

Vu Ngoc
Stepan Lomov
Abderrahmane Ayadi
Julia Orlik
Yordan Kyosev
Oussama Haji
Valter Carvelli
De Luycker Emmanuel
Philippe Boisse

Applicants (non members)

Laurent Orgeas
Stephen Hallett
Krishna Mohan
Juan Manuel González
Angela Madeo
Marco Valerio d'Agostino
Adam Thompson
Ulrich Sachs
Francisco Chinesta
Zhaofei Xiao
Thierry Antonini
Radmir Karamov
Andrey Vasilyev
Arturo Mendoza
Preetamkumar Mohite
Xiongqi Peng
Damien Durville
Mathieu Imbert
Vijay Sahadevan
Yanneck Wielhorski
Yoshihiko Kanda
Dominik Dörr
Luise Kärger
Thomas Gereke
Arjun Radhakrishnan
Lourens Blok
Arbia Nouigues
Benjamin Gröger
Kristof Vanclooster
Lukas Münch
Rita de Cassia Costa Dias
Christian Poppe

Shenglei Xiao
Mark Turk
Rohit George Sebastian
Teixera Marie
Omar Baho
Peng Wang
David Colin

Cédric DESCAMPS Euromech fees for five years
Christian Garnier Euromech fees for five years

Number of participants from each country

COUNTRY	PARTICIPANTS
Belgium	3
France	20
Canada	1
Austria	2
United Kingdom	7
Germany	11
Italy	1
China	1
India	2
Russia	2
Poland	1
Netherlands	1
Spain	1
Japan	1
TOTAL	54

Please send this report in electronic form to the Secretary General of EUROMECH, within one month after your Colloquium.