https://compositeskn.org/KPC/A136

A136

Dr. Anoush Poursartip's cdmHUB global composites expert webinar

Perspectives article

Document Type	Article
Document Identifier	136
Themes	• [Thermal management]
Tags	• [System uncertainty] • [System optimization and robustness] • [Governing science] • [Process modelling] • [Thermoset cure kinetics] • [Thermal transformation]

Video links

Dr. Anoush Poursartip's webinar recording

• https://cdmhub.org/resources/1895

All Global Composites Experts Webinar Series recordings

• https://cdmhub.org/resources/1890

Introduction[edit | edit source]

In the summer of 2020, the Purdue Composites Design & Manufacturing HUB (cdmHUB) organized a series of webinars presented by global composites experts. These webinars examine the history, present capabilities, and future of composites science and technology, with the goal of sharing the vast knowledge of composites that has been developed over the past 50 years. CKN Co-Director Dr. Anoush Poursartip was the inaugural speaker.

Abstract[edit | edit source]

Composite materials and structures are an excellent example of how engineering practice often outpaces scientific knowledge. Born in the analog world of the 1960s, carbon-fibre composites manufacturing and design practice is a complex and often fragile construct that is primarily driven by the need to . In the last two decades, the packaging of knowledge in the form of predictive simulations supported by characterized materials and standardized workflows has started to change this paradigm, but the best is yet to come. In this presentation, Dr. Poursartip charts the history of process simulation and in-process measurement & control to highlight how scientific knowledge is becoming good enough to disrupt current engineering practice. Dr. Poursartip posits that the specific needs of our domain can only be met with the strategic and careful merging of two previously separate digital threads, namely science-based Integrated Computational Materials Engineering (ICME) with data-based Industry 4.0. Using examples from his own 40-year career bridging academic research and industrial practice, Dr. Poursartip highlights how digital strategies

will be even more important to our community as we emerge from the current economic crisis.

Video link[edit | edit source]

The recording of Dr. Poursartip's presentation can be viewed at the cdmHUB's website here[1].

Other presentations in the cdmHUB's global composites expert webinar series can be viewed found here.

Video timeline[edit | edit source]

Time	Focus	Links to related information in the Knowledge in Practice Centre
00:00	Welcome and introduction to the cdmHUB	N/A
02:16	Introduction of Dr. Anoush Poursartip	N/A
04:07	Acknowledgments	N/A
04:44	Background on historical composites manufacturing practice	Future content
06:41	Digitalization of composites & digital manufacturing	Future content
08:14	The "digital twin"; a virtual manufactured part	Future content
09:57	A typical prepreg composites factory and the early use of a virtual twin for thermochemical cure modelling	Future content
12:15	The virtual twin for cure modelling today	Future content
14:15	The virtual twin for cure modelling today - Predicting the effect of equipment and tooling	• Thermal management - A107 • Effect of equipment in a thermal management system - A110 • Effect of tooling in a thermal management system - A142
15:48	The virtual twin for cure modelling today - Designing the equipment, tooling and thermal cycle	• Practice for developing a thermal transformation process step - P105
17:12	Today's virtual twin for forming processes	Future content
19:17	Today's virtual twin for autoclave processes	Future content
20:07	Merging science-based simulation and data-driven modelling - Theory guided machine learning	Future content
25:27	Science-based data analytics of autoclave production data	Future content
29:47	Uncertainty quantification in material models and simulation	Future content
34:16	Manufacturing simulation to support the disruption of current practice	Future content
34:52	Manufacturing simulation to support the disruption of current practice - The temperature history's effect on fracture properties of thermoplastically toughened epoxy	Future content
40:08	Data to support the disruption of practice	Future content
41:54	The Digital Learning Factory as a method for generating process data	N/A

43:25 Summary	N/A
44:38 Acknowledgments	N/A
45:03 Q&A	N/A

Related pages

Page type	Links
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Foundational Knowledge Articles	• Conduction - A118 • Convection - A106 • Glass transition temperature (Tg) - A210 • Heat of reaction - A114 • Heat transfer - A132 • Materials science - A235 • Processing science - A151 • Thermal behaviour - A232 • Thermal phase transitions of polymers - A102 • Thermoplastic polymers - A161 • Thermoset polymers - A105 • Viscosity (resin) - A203
Foundational Knowledge Method Documents	
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Systems Catalogue Objects – Tooling and consumables	
Systems Catalogue Objects – Equipment	• Rheometer - A357
Practice Documents	• Decreasing Cure Cycle Time - P121 • Practice for developing a thermal transformation process step - P105 • Troubleshooting scale-up issues from thin to thick parts - P140 • Troubleshooting scaling-up issues from coupons to parts - P134
Case Studies	• Troubleshooting of room temperature processes for large recreational and industrial parts - C100

Perspectives Articles	• Case Study: Optimizing a Press Moulding Process - A324 • Composite materials engineering webinar session 3 - Constituent materials - Resin - A122 • Composite materials engineering webinar session 4 - Thermal management and resin cure - A123 • Composites Process Simulation: A Review of the State of the Art for Product Development - A283 • Dr. Anoush Poursartip's cdmHUB global composites expert webinar - A136 • Fabric Forming: how it affects design and processing, and how simulation can address this - A310 • Interview with Prof. Kevin Potter - A134 • Resin Behaviour During Processing: What are the key resin properties to consider when developing a manufacturing process? - A257 • Simulation models for rapid liquid composite molding - A333.0 • Understanding Polyester Resin Processing: The Effect of Ambient Temperature on the Final Part - A286

References

1. ↑ [1.0] [1.1] [Ref] Poursartip, Anoush (2020), *Digital disruption of composites manufacturing and design*, Purdue University cdmHUB (published 10 October 2020)

About **Help**

Any manufacturing and/or decision making activity that occurs during any stage of the development design cycle (e.g. conceptual design to production).

In the context of Knowledge in Practice, practice refers to the systematic use of science based knowledge to reduce composites manufacturing risk, cost, and development time.

In the context of knowledge in practice, knowledge refers to the systematic use of science based knowledge in composites manufacturing practice.

There is a distinction between experience based knowledge and science based knowledge:

- Experience based knowledge (‘know-how’) is an understanding of potential outcomes and their relationships that is founded on pragmatism and experience accumulated over time in individual programs, companies and in the industry more broadly.
- Science based knowledge (‘know-why’) is an understanding of potential outcomes and their relationships, based on the important processing physics, that is mature enough to be codified using the appropriate governing laws and constitutive equations.

A set of steps/procedures that are intended to provide guidance in manufacturing and/or decision making activities.

There are two types of workflows:

- *Standard workflows* are intended to formalize practices where the manufacturing science base exists. The focus is to provide guidance using manufacturing simulation as an enabling tool (e.g. design activities/decisions relating to thermal management).
- *Complex workflows* are intended to reduce the level of effort in practices where the existing manufacturing science base is not sufficiently mature to support production scale problems. The focus is to provide guidance using simulation based thinking and/or checklists (e.g. design activities/decisions relating to porosity management).

Pre-impregnated (prepreg) material refers to fibre that is already combined with resin. It is the most common material form used in aerospace.

During prepreg production, (e.g. fibres are run through a resin bath), prepreg is heated and partially cured to B Stage (< 5 % degree of cure). Thermoset prepregs (e.g. epoxy prepreg) have to be kept in a freezer at around -20 °C. At room temperature, the epoxy starts to cure.

The use of multiphysics models to predict the outcome of real-world scenarios. May be analytical (closed form, "hand calculations") or computational (implementation on computers is required due to the large number of calculations involved. e.g. finite element method, finite difference method)

Most often in composite materials engineering, modelling refers to either:

- Process modelling (predicting manufacturing outcomes, or the inverse problem of predicting manufacturing parameters to achieve a desired outcome), or
- Performance modelling (predicting the stiffness/strength/suitability of a structure, or the inverse problem of the material properties and dimensional requirements to achieve a desired stiffness/strength/suitability of a structure)

(same as "Simulation")

The use of multiphysics models to predict the outcome of real-world scenarios. May be analytical (closed form, "hand calculations") or computational (implementation on computers is required due to the large number of calculations involved. e.g. finite element method, finite difference method)

Most often in composite materials engineering, simulation refers to either:

- Process simulation (predicting manufacturing outcomes, or the inverse problem of predicting manufacturing parameters to achieve a desired outcome), or
- Performance simulation (predicting the stiffness/strength/suitability of a structure, or the inverse problem of the material properties and dimensional requirements to achieve a desired stiffness/strength/suitability of a structure)

(same as "Modelling")