A1

Home

Document Type	Article
Document Identifier	1

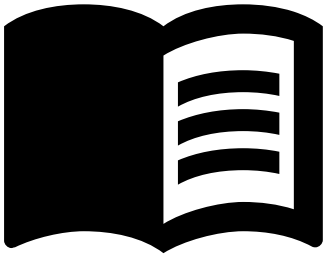
Welcome to the Knowledge in Practice Centre (KPC). The KPC is a resource for learning and applying scientific knowledge to the practice of composites manufacturing. By clicking the links below, you can access the latest composites knowledge and best practices for different types of manufacturing and applications.

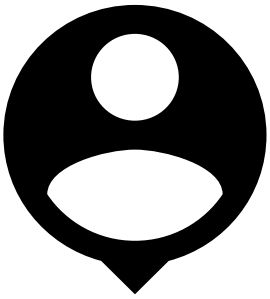
Want to learn more about how to navigate the KPC? Find more information at Level II.

Level I
Level II

Practice

Read more





Systems Catalogue
Practice
Case Studies

Perspectives

Do you want to gain more information about the items in your factory, from material through to equipment? Are you in the market to purchase a piece of equipment and want to know more about the specifications? The Systems Catalogue volume lays all this out in a structured manner, with a link to CKN's Resource Directory included. Click here to explore the Catalogue volume.

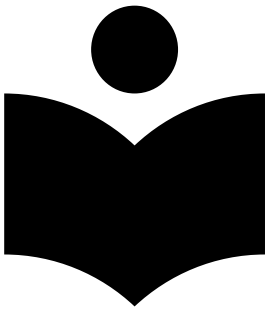
Are you here to learn how to develop, optimize, or troubleshoot your manufacturing process? Defining the necessary process steps for your application can seem challenging. In addition to this, the factory layout must also be defined. The Practice volume provides guidance for practitioners to navigate the realm of composites manufacturing. Click here to explore the Practice volume.

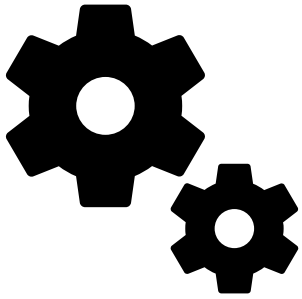
Are you interested in seeing examples of the challenges and learning outcomes of composite manufacturing practice? The Case Studies volume provides real world situations where practitioners had to develop, optimize, or troubleshoot their manufacturing process(es). It ties in directly and provides context to the Practice volume. Click here to explore the Case Studies volume.

Would you like to learn from leading industry experts? The Perspectives volume contains links to videos, webinars, and other multimedia content delivered by industry professionals. Click here to explore the Perspectives volume.

Knowledge

Read more





Introduction to composites
Foundational Knowledge
Systems Knowledge

Are you new to composite materials and/or manufacturing and would like to learn more? Would you like to learn more about the KPC framework for composites manufacturing? The Introduction to Composites volume provides background information on composite materials and processing. Additionally, a high-level breakdown of composite manufacturing into a systems-level approach is provided. Click here to explore the Introduction volume.

Would you like to gain a deeper understanding of the science behind composite materials and manufacturing? The Foundational Knowledge volume covers topics from material science through to processing science. Click here to explore the Foundational volume.

Would you like to learn more about how the components of a process interact? For example, what happens if you change the tooling in your system? Or what if you have a thick part? The Systems Knowledge volume covers the interaction between components and how these influence the outcomes of the part. It is laid out according to the KPC's framework for a system's level approach to composites manufacturing. Click here to explore the Systems Knowledge volume.

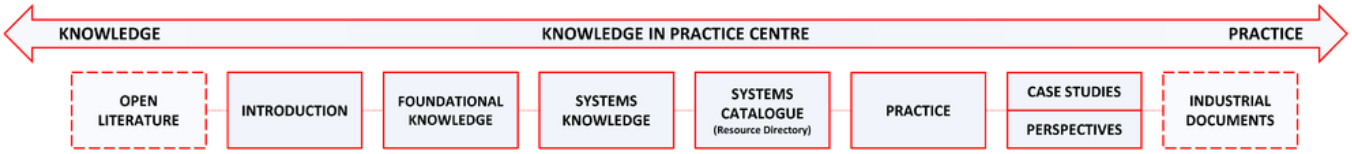
How to use the KPC[edit | edit source]

KPC Framework[edit | edit source]

The Knowledge in Practice Centre (KPC) is a subset of the Composites Knowledge Network (CKN) initiative intended to provide value to Canadian SMEs looking to expand their capabilities within the realm of composites engineering. The KPC follows a generalized framework for composites manufacturing, wherein manufacturing is examined using an object-oriented approach.

Volumes[edit | edit source]

The layout of the KPC is organized according to a systems-level hierarchical approach, containing seven different but interconnected volumes. These are: Introduction to Composites, Foundational Knowledge, Systems Knowledge, Systems Catalogue, Practice, Case Studies, and Perspectives. Conceptually, preceding these volumes is open literature representing fundamental knowledge. On the other end, proceeding these volumes are industrial documents, representing industrial best practice.



KPC Layout

Approach[edit | edit source]

Link to systems approach to composite materials

Typically, composite manufacturing processes are named after one or more critical processing steps. This shorthand notation is often adopted to describe the process as a whole. What results from this is that each manufacturing process is often viewed as different from the other processes. This is not necessarily true, however. A process is not unique in the sense that it is fundamentally different from other manufacturing processes, rather a process is unique because of the arrangement of its process steps, inclusion/exclusion of specific steps, and/or differences in the equipment, tooling, shape, and material involved. Indeed many composite manufacturing processes contain very similar steps. For example, a thermoset RTM and autoclave prepreg process differ in their initial material state, requiring specific process steps and therefore different equipment. However, they both undergo the same general steps. Material is deposited on a tool, thermal energy is applied to cure the material, the material is taken off the tool, inspected, and then assembled into the final part. Therefore, describing all of a composite manufacturing workflow by a single process step does not capture the nuances of the entire workflow, and can even be constraining. More importantly, it discourages similarities between processes to be drawn. Such similarities are important in understanding how best to layout a factory.

A process is nothing more than a set of equipment and tooling used to perform a specific process step on the part or material. Therefore, the manufacturing workflow is dictated by the steps performed by equipment and tooling. Defining which steps to perform and which equipment and tooling to use is based on the material state and the part shape. In other words, it is the part and material that determine which process steps must be performed and which equipment/tooling can be used to perform them. The layout of these process steps are what define the manufacturing

workflow.

The process steps must occur within a physical space in the factory. This is what is referred to as a factory cell. The part flows through the factory, taking shape with each successive process step it undergoes. Depending on the factory layout, there may be multiple process steps that occur within the same physical space (cell) in the factory.

To learn more about this approach, navigate to the link presented above or click here.

KPC Features[edit | edit source]

Levels of Detail[edit | edit source]

Each page of the KPC may be subdivided into different levels of detail, designated as "Level I", "Level II" and "Level III". You may see only two different levels, or you may see all three depending on the complexity of the subject being covered, and the current level of detail of that page. The idea behind the different levels is to provide you with the most appropriate experience for navigating the KPC based on your preference. If you'd just like to gain a broad understanding of a particular subject, level I might be the most appropriate. On the other hand, if you are very interested in the fine details of a subject, level III may be best for you; or you may just switch between them to simultaneously develop a strong high level understanding (level I) while filling in the important details (level III). In general, the different levels can be described as:

- **Level I** is suitable for those new to composites who would like to navigate through the site and learn about composites processing at the highest level. The same concepts covered in the other levels are discussed, but without the focus on the minutiae. It is most appropriate for users who wish to build an understanding of composites manufacturing and become aware of the intricacies involved while analyzing problems based on what they see and observe in the process.
- **Level II** is appropriate for those who would like to develop their understanding of composites manufacturing at a greater level of detail and understand how to analyze problems using simple, convenient methods.
- **Level III** is suitable for those who wish to master their understanding of composites manufacturing and understand how to analyze problems at the highest level of detail for the most complex problems.

Content[edit | edit source]

Practice[edit | edit source]

Systems Catalogue[edit | edit source]

Do you want to gain more information about the items in your factory, from material through to equipment? Are you in the market to purchase a piece of equipment and want to know more about the specifications? The Systems Catalogue volume lays all this out in a structured manner, with a link to CKN's Resource Directory included. Click here to explore the Catalogue volume.

Practice[edit | edit source]

Are you here to learn how to develop, optimize, or troubleshoot your manufacturing process? Defining the necessary process steps for your application can seem challenging. In addition to this, the factory layout must also be defined. The Practice volume provides guidance for practitioners to navigate the realm of composites manufacturing. Click here to explore the Practice volume.

Case Studies[edit | edit source]

Are you interested in seeing examples of the challenges and learning outcomes of composite manufacturing practice? The Case Studies volume provides real world situations where practitioners had to develop, optimize, or troubleshoot their manufacturing process(es). It ties in directly and provides context to the Practice volume. Click here to explore the Case Studies volume.

Perspectives[edit | edit source]

Would you like to learn from leading industry experts? The Perspectives volume contains links to videos, webinars, and other multimedia content delivered by industry professionals. Click here to explore the Perspectives volume.

Knowledge[edit | edit source]

Introduction to Composites[edit | edit source]

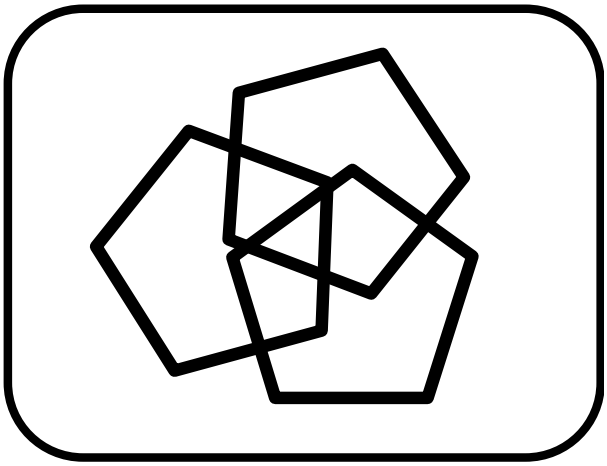
Are you new to composite materials and/or manufacturing and would like to learn more? Would you like to learn more about the KPC framework for composites manufacturing? The Introduction to Composites volume provides background information on composite materials and processing. Additionally, a high-level breakdown of composite manufacturing into a systems-level approach is provided. Click here to explore the Introduction volume.

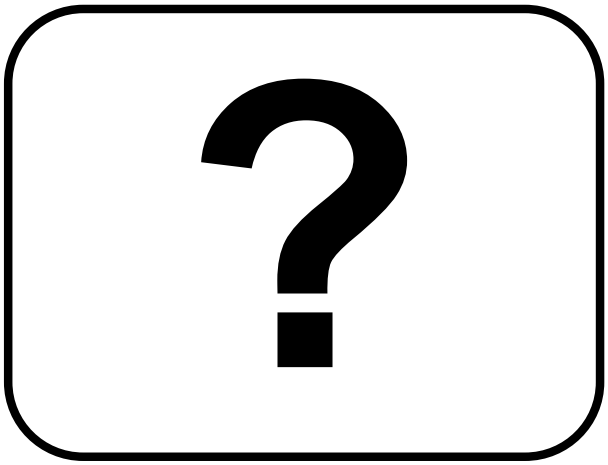
Foundational Knowledge[edit | edit source]

Would you like to gain a deeper understanding of the science behind composite materials and manufacturing? The Foundational Knowledge volume covers topics from material science through to processing science. Click here to explore the Foundational volume.

Systems Knowledge[edit | edit source]

Would you like to learn more about how the components of a process interact? For example, what happens if you change the tooling in your system? Or what if you have a thick part? The Systems Knowledge volume covers the interaction between components and how these influence the outcomes of the part. It is laid out according to the KPC's framework for a system's level approach to composites manufacturing. Click here to explore the Systems Knowledge volume.





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.

Engineered materials (designed to have specific properties) made from two or more constituent materials with different physical or chemical properties. The constituents remain separate and distinct on a macroscopic level within the finished structure.

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.

Thermosets are a class of polymer that undergo polymerization and crosslinking during curing with the aid of a hardening agent and heating or promoter. Initially they behave like a viscous fluid. During curing, they change from viscous fluid to rubbery gel (viscoelastic material) and finally glassy solid.

If heated after curing, initially they become soft and rubbery at high temperatures. If further heated, they do not melt but decompose (burn)

Comes in two parts: part A (resin) and B (hardener). When mixed, curing reaction starts and is not reversible.

Examples include epoxy or polyester.

Resin transfer moulding (RTM) involves loading a preform into a two (or more) piece, matched tool, closing it, and injecting resin under pressure (~15-100 psi, or ~1-7 bar).

Well suited to small to medium sized parts, limited to large sizes due to injection pressure loads and tool cost.

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.

An individual station within a factory where a given set of tasks are accomplished (also known as a "work cell"). Some cells may directly add value to the product (e.g. deposition), while others may serve support roles that are critical to maintaining part quality (e.g. receiving, storage, inspection & shipping).