Composites and Structures

Session Time: One, 50-minute session

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

Aspire to the highest level of technical proficiency as it relates to flight operations and engineering practices. (EU5)

Develop an uncompromising safety mindset, understanding that growth and development in the aviation/aerospace industry must always be accompanied by responsive safety initiatives. (EU6)

ESSENTIAL QUESTIONS

1. Do composite materials promise to be the aviation and aerospace construction material of the future?
2. What are their advantages over more traditional materials, such as metals?

LEARNING GOALS

Students Will Know

- A variety of uses for composites
- Benefits and drawbacks to composite materials
- Qualities that composites must have for aviation and aerospace applications

Students Will Be Able To

- *Formulate* criteria for the use of composites in aircraft design. (DOK-L3)
- *List* ways in which composites are used in aviation and aerospace. (DOK-L1)

ASSESSMENT EVIDENCE

Warm-up
Students will develop a list of items they know of that are made with composite materials. They will compare the benefits/potential drawbacks of using composites for the items they listed.

Formative Assessment
Students will work in small groups to consider ways in which composites are used on aircraft and spacecraft today and how composite materials may be used in the future.

Summative Assessment
Students will create a "work order" with their top five criteria for a new composite material for a future aircraft.

LESSON PREPARATION

MATERIALS/RESOURCES

- Composites and Structures Presentation
- Composites and Structures Student Activity 1
- Composites and Structures Student Activity 2 **(Going Further)**

Build-Your-Own Composite Activity (Going Further)

- Balance or digital scale
- Graduated cylinders (50-100 mL, several per class or one per group)
- Counterweights or other weights (i.e. books) to test strength
- Measuring cups and spoons (several per class, or one per pair or group)
- Several types of flour for use in making paste
- Warm water
- Materials to cover work surfaces
- Vaseline
- Variety of fabrics (biodegradable and other), such as paper towels, newspaper, tulle, cotton, burlap, nylon, etc. Each student will need several strips of one or two types of fabric about 2 inches x 6 inches.
- Mixing bowls and utensils for making paste (per group)
- Empty plastic containers to use as molds (empty yogurt cups, sour cream containers, margarine tubs work well).
- Safety goggles

LESSON SUMMARY

Lesson 1: Fly-by-Wire and Glass Cockpits

Lesson 2: Aircraft Navigation

Lesson 3: Composites and Structures

The warm-up activity asks students to create a list of items they may already use that are made from composite materials. They will compare these materials with what the items used to be made from.

During a class discussion, students will learn what a composite is and their advantages and disadvantages. Special emphasis will be placed on the need for materials to be strong, lightweight, and able to withstand heavy, repeated vibrations and fluctuations in pressure and temperature. Students will be asked to consider ways in which composites are used on aircraft and spacecraft today and how composite materials may be used in the future.

Finally, students will be evaluated by creating a “work order” for a new composite material for a future aircraft. The work order will contain a top five list of qualities the material needs to have, along with a justification for those qualities.

As an option for going further, students can work with partners to create their own composite structure from strips of fabric and paste mixtures. They will be able to choose from various fabrics and decide how to mix their paste (selecting the flour type as well as flour/water ratio). They will use a mold to shape their new composite materials, and qualitatively test its strength when dry.

BACKGROUND

Composite materials have existed for a long time. Composites are defined as “two or more materials that are combined to achieve more desirable properties.” Each composite is made of different materials based on the qualities these materials need to have. For example, if the focus is on a lightweight material, then the composite will be composed of components that do not weigh much. If rigidity is a needed strength, then that will be the focus. Many composite materials require more than one criteria, however, which requires much testing to develop the best set of qualities possible.

Aircraft and spacecraft composites have specific needs and requirements. Safety is always a critical quality, so materials need to be evaluated carefully in order to ensure quality control. In addition, aircraft and spacecraft are exposed to wide fluctuations in temperature and pressure, so they need to keep their shape and rigidity in both heat and cold.

Aircraft must withstand changes in air pressure, often several times a day for a commercial aircraft. As aircraft rise higher in Earth's atmosphere, the outer part is exposed to a decrease in air pressure. The inside cabin is then pressurized with air for passenger safety and comfort, exerting more pressure on the inside of the aircraft with less pressure pushing back from the outside. However, as an aircraft descends and lands, more air pressure on the outside pushes on the aircraft skin. Spacecraft also face this change in pressure but not as often as aircraft.

Because aircraft must withstand fuels and solvents, many aircraft composites are made with a metal matrix composite, or MMC, that uses a fiber reinforcement in a metal matrix.

Lightweight materials are better for aircraft and also reduce fuel consumption. Because fuel costs are one of the most costly parts of operating commercial aircraft, weight reduction is a huge economic consideration for commercial airlines. One way some composites add strength yet reduce weight is to utilize the strength of a honeycomb shape, which takes advantage of many small pockets of air within the structure.

Composites also have some disadvantages. They are most complex to produce, are subject to delamination between layers, the carbon fiber material is expensive, and can be more difficult to inspect. Many years of testing are involved in developing a new composite because there are so many variables. As new needs emerge in the aeronautics and space fields, new qualities and composites will emerge to meet these needs.

MISCONCEPTIONS

Students may not be aware of how many items exist that utilize composite materials or why composites are being used. Particular focus should be spent highlighting the specific needs that materials must have in order to be used for aviation or aerospace applications.

DIFFERENTIATION

To support student engagement in the **EXTEND** section, arrange for students to have a hands-on experience with various types of composite materials used on aircraft. This allows learners to be involved in a highly engaging, active learning experience.

LEARNING PLAN

ENGAGE

Teacher Material: Composites and Structures Presentation

Slides 1-3: Introduce the topic and learning objectives of this lesson.

Slides 4-6: Conduct the **Warm-Up.**

After students list different items made from composite materials, allow them to share their list with their classmates. In a class discussion, ask students to give pros and cons of using composites for the items they listed. [DOK-L1; identify; list]

Warm-Up

Ask students to list all the items they can that are made of composite materials (baseball bats, car parts, etc.) and compare them with what these items were previously made from.

Questions

Possible answers include:
Parts in cars and automobiles, tennis rackets, golf clubs, fishing rods, helmets, boats, skateboards and bicycles.

Teaching Tips

A potential alternative to the **Warm-Up** exercise would involve having students do a scavenger hunt around the classroom for examples of composite materials and then allowing for the discussion and writing assignment listed above.

EXPLORE

Teacher Material: Composites and Structures Presentation

Slide 7: Show the video about the new Boeing 787 Dreamliner, which is primarily made from composite materials, most notably the entire fuselage. While students are watching the video, ask them to write down advantages of using composites for aircraft manufacturing.

Students may list advantages including:
Increased strength and durability, lightweight, favorable fatigue characteristics, and anti-corrosion characteristics.

- "Boeing 787: Game-changing Innovation" (Length 2:37)
  http://video.link/w/QxMd

EXPLAIN

Teacher Material: Composites and Structures Presentation

Slide 8: Composites are defined as "two or more materials that are combined to achieve more desirable properties," which means there have been many types of composites over the years. Each composite is made of different materials based on the qualities these materials need to have. For example, if the focus is on a lightweight material, then the composite will be composed of components that do not weigh much. If rigidity is a needed strength, then that will be the focus. Many composite materials require more than one criteria, however, which requires much testing to develop the best set of qualities possible.

Slide 9: Describe the advantages of composites to students. Composites are known for the enhanced strength and stiffness they give to objects, such as airplane wings, while being lighter than conventional materials. Objects made from composites can also hold their shape better and not experience fatigue under heat or pressure.

Emphasize to students that their strength-to-weight ratio exceeds many other materials and is a key reason why they are so desirable for use in aviation and aerospace applications.

Slide 10: The fabrication process for composites is complex and requires specialized equipment and expertise. The fabrication process is usually labor intensive and complex, which further increases cost.

Since composites are often constructed of different ply layers into a laminate structure, they can "delaminate" between layers where they are weaker. Further, delamination and cracks in composites are mostly internal and sometimes require complicated inspection techniques for detection.

Slide 11: Conduct the **Formative Assessment.**

Once the small groups are finished compiling their written responses, collect them for grading and ask students to share their answers. Students may use the Internet to research some ideas. [DOK-L2; infer; predict]

Formative Assessment

In small groups, ask students to write down ways in which composites are used on aircraft and spacecraft today and then list ways composites may be used in future designs. Ask students to share their answers with the class.

Questions

Ways in which composites are used today:

Fuselages, propellers and rotor blades, wings and winglets, seats, and instrument panels.

Future uses in aviation for composites:

Engine components, aircraft components other than the fuselage and wings (like landing gear), rocket and spacecraft structures.

EXTEND

Teacher Material: Composites and Structures Presentation

Slide 12: Describe how composite requirements for aircraft and spacecraft are different than those for other products because of the extreme fluctuations in temperature, continuous vibration, and other conditions they come under in harsh environments. Students will look at composites as they relate to aircraft and spacecraft and the special considerations that must be taken to use them.

Slide 13: During this discussion, emphasize the importance of quality control for composite materials. Explain to students quality control is a system of maintaining standards in manufactured products. It is a review of all the factors involved in production. Inspections are a major component of quality control where the physical product is examined for defects like cracks, blemishes or other imperfections.

Show students a video of a composites technician describing his job. After they watch the video, ask students what skills the composites technician featured in the video needs to do his job. Ask them what his role is in maintaining quality of the product.

- "What is a Composite Technician" (Length 2:09)
  http://video.link/w/3MVd

Teaching Tips

If time allows, provide students with several examples of composite materials and allow them to visually inspect and evaluate those materials.

EVALUATE

Teacher Material: Composites and Structures Presentation
Student Material: Composites and Structures Student Activity 1

Slide 14: Conduct the **Summative Assessment.**

Provide students with **Composites and Structures Student Activity 1** which they will use to simulate the creation of a new composite. Students will be asked to consider what qualities that the composite materials should have. After students have completed the assessment, collect it for grading purposes. Grade student work using the Scoring Rubric. [DOK-L3; assess; develop a logical argument]

Summative Assessment Scoring Rubric

- Follows assignment instructions
- Student work shows evidence of one or more of the following:
- An understanding of composite materials
- Ability to assess the appropriate types of materials needed for the aircraft
- An explanation about why the level of quality is needed for the composite materials
- Student work shows overall understanding of the concepts covered in the lesson

Points	Performance Levels
9-10	Consistently demonstrates criteria
7-8	Usually demonstrates criteria
5-6	Sometimes demonstrates criteria
0-4	Rarely to never demonstrates criteria

Summative Assessment

Students will develop a "work order" for a new composite material needed for a future aircraft. The work order will include a list of the top five qualities the new material needs to have, along with a brief justification for those criteria.

GOING FURTHER

Teacher Material: Composites and Structures Presentation

Slides 15-17: Students may build their own composite using several different materials to create a "textile composite," working with variables such as fabric/material type, and paste consistency. They will test the effects of these variables. To guide students, provide them copies of **Composites and Structures Student Activity 2**.

STANDARDS ALIGNMENT

NGSS STANDARDS

Three-dimensional Learning

- **HS-ETS1-1** - Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
    - Science and Engineering Practices
        - Asking Questions and Defining Problems
        - Constructing Explanations and Designing Solutions
    - Disciplinary Core Ideas
        - ETS1.A: Defining and Delimiting Engineering Problems
    - Crosscutting Concepts
        - Systems and System Models
        - Influence of Science, Engineering, and Technology on Society and the Natural World
- **HS-ETS1-2** - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
    - Science and Engineering Practices
        - Constructing Explanations and Designing Solutions
    - Disciplinary Core Ideas
        - ETS1.C: Optimizing the Design Solution
    - Crosscutting Concepts
        - none
- **HS-ETS1-3** - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
    - Science and Engineering Practices
        - Constructing Explanations and Designing Solutions
    - Disciplinary Core Ideas
        - ETS1.B: Developing Possible Solutions
    - Crosscutting Concepts
        - Influence of Science, Engineering, and Technology on Society and the Natural World

COMMON CORE STATE STANDARDS

- **RST.9-10.1** - Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

- **RST.9-10.2** -Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- **RST.9-10.4** - Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
- **RST.9-10.7** - Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- **WHST.9-10.2** - Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- **WHST.9-10.4** - Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- **WHST.9-10.6** - Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
- **WHST.9-10.7** - Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- **WHST.9-10.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
- **WHST.9-10.9** - Draw evidence from informational texts to support analysis, reflection, and research.

REFERENCES

https://www.nasa.gov/sites/default/files/atoms/files/composites_k-12.pdf
http://www.dexcraft.com/articles/carbon-fiber-composites/aluminium-vs-carbon-fiber-comparison-of-materials/