Engineering Seminar # 4: Nanostructured Composite Materials

Speaker: Dr. Jandro Abot, Assistant Professor, Department of Aerospace Engineering, University of Cincinnati
Date: July 1, 2009
Time: 3:00 to 5:00 p.m. (2 hours)

Prepared by:
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This seminar was given by Dr. Jandro Abot, Assistant Professor, Department of Aerospace Engineering, University of Cincinnati on July 1, 2009 in 641 Baldwin Hall from 3:00 to 5:00 p.m.

The seminar started by presenting a wide array of examples of where composite materials are used in the real world. This included:

(a) Aerospace
    1. Boeing 787 most of fuselage and wings are composite materials
    2. Military aircraft
    3. Airbus 380
    4. Comanche helicopter
    5. B2 bomber - all composites!
    6. Rocket/plane
    7 Satellites
(b) Public transport: High speed trains
(c) Ships
(d) Wind Turbines: Example, Delaware wind project
(e) Oil drilling
(f) Biomedical applications: Prosthesis
(g) Civil infrastructures: Bridges: replacing steel and/or concrete decks with composite decks

Next, what is a composite material was discussed. It consists of:

1. Two phases combined together in a matrix.
2. Layers of thin core material made of a sandwich carbon fiber, glass, and Aramid (Kevlar and Zylon-polymeric fibers).
3. A matrix polymer, ceramic, metal, etc. to bind them together.

Next the material characteristics were discussed. It was pointed out that the advantages of composites were: (1) strength; and (2) reduction in corrosion, environmental damage, and fatigue. The behavior of any material is described by its stress and strain curve. All materials have a specific stress strain relationship. Many have a linear relationship, for which two most important mechanical properties are: (1) elastic modulus of elasticity (the slope of the linear line) and (2) strength (the value of the stress when the material fails). Comparatively, carbon/epoxy composites have a much higher specific strength than metals. This is the reason why they are so valuable for use in aircraft structures. The area under the stress-strain curve represents the stored strain energy in the material.

Dr. Abot passed around samples of composites materials and asked the teachers to bend and flex them to see first hand how they behaved. He then explained the difference in the materials of each sample, and related it to the differences in their behavior.

For large shaped structures, specific molds are used to cast the composite shape. Dr. Abot pointed out that a fiber material is not used in such cases because one needs to then consider the direction of the weave. In such cases fiber wrapping is used. In such composite materials, due to impact force the fibers are susceptible to the risk of breaking. But, once the fibers are broken, they are useless. The drawbacks

with composites are: strength of the material is provided for in-plane loading, however in shear and transverse loads the structure fails much more quickly.

Structural health monitoring was also discussed. The technologies used include piezoelectric, fiber brag grating, fiber optic, and ultrasonics (sound waves). These techniques are expensive, and often require the structure to be out of service during testing for an extended period of time. To overcome this problem Nanostructured and Self Sensing Composites are used, which can be used to determine failures and flaws in real time. These can be as small as a micron and below. In such materials carbon nanotubes (CNT) are used to develop a network of sensors to determine how much strain is produced to predict delamination. Dr. Abot discussed that he has been working to develop such a sensor using CVD (chemical vapor deposition process) and heat to grow fibers on a catalyst seeded Si wafer that are then spun into a thread to create a network of CNT threads that we can be incorporated into a matrix.

The seminar ended with a discussion on how the knowledge presented can be used to enhance math and science skills of students. Following examples were discussed:

- Chemistry - chemical bonds.
- Math - relationships between characteristics of materials.
- Physics - predicting how materials behave (stress-strain behavior).

It was pointed out that students are losing ability in math and science by the time they reach upper levels in high school. To be successful in college, students need to have a strong background in math and science. The reason may be that students do not see the connection of the concepts taught in the class to real world applications and their societal impact. This seminar provided ideas to the teachers to bring this experience into their classroom.