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Guest Lecture organized by Department of Aeronautical and Aerospace Engineering

Report on the Guest Lecture

“Composite Radome characterization for Airborne Application”

Date of the event	06/03/2025
Title of the Event & Lecture	Guest Lecture on “Composite Radome characterization for Airborne Application”
Name of the Resource Speaker	Mandeep Singh, Sc ‘E’Centre for Airborne System (CABS), DRDO
No.of Participants	100
Venue	Seminar Hall 3

The Department of Aeronautical and Aerospace Engineering organized a guest lecture on **"Composite Radome characterization for Airborne Application"** on March 06, 2025. The event took place at Seminar Hall 3, starting at 01:30 PM. The expert speaker, Mandeep Singh, Sc ‘E’**Centre for Airborne System (CABS), DRDO**, delivered the lecture. Students from various engineering departments attended, making it an engaging and insightful session.

The program began with Dr.Niranjanappa, Dean of research, welcoming the guest. The event was graced by the presence of Dr. Shrinivas L Gombi, Dean Academic MVJCE, Bangalore.

Dr. Niranjanappa introduces the chief guest

During the session, the speaker shared valuable experiences in the DRDO Lab focusing on the composite development for various projects. The session was interactive, encouraging students to ask questions and openly discuss challenges. The guest introduced the concept of composite materials and their significance in the design and application of radomes, particularly in airborne systems. The speaker, an expert in the field of aerospace engineering, discussed the types of composite materials used in radome construction, their advantages, and the challenges in characterizing these materials for use in airborne applications.

The speaker began with an overview of composite materials, explaining that composites are engineered materials made from two or more distinct components: a matrix and a reinforcement. The matrix binds the reinforcement together, providing structure and protection, while the reinforcement adds strength, stiffness, and other specific properties. The most used composites in radome applications include fiberglass, carbon fiber, and aramid fiber, often combined with epoxy or thermoplastic matrices. Composites are chosen for their light weight, durability, and resistance to environmental factors.

Dr. Ganapathi, Professor Aerospace, offering a traditional gesture to the Chief Guest, Mandeep Singh, Sc 'E'

The lecture delved into the types of composites used in airborne radomes:

- **Fiber Reinforced Composites (FRPs):** These are the most common composites, with fibers (glass, carbon, aramid) embedded in a matrix material. They offer high strength-to-weight ratios and are ideal for aerospace applications.

- **Ceramic Matrix Composites (CMCs):** CMCs are also used in some specialized applications due to their high resistance to high temperatures and corrosive environments.

- **Metal Matrix Composites (MMCs):** Although less common for radomes, MMCs are used in applications requiring high conductivity and strength.

Students attentively listen to the lecture.

The advantages of using composite materials for radomes, particularly in airborne applications, include:

- **Lightweight:** Composites offer excellent strength-to-weight ratios, which is critical for airborne systems to minimize payload and improve fuel efficiency.
- **Electromagnetic Transparency:** Radomes must allow for the unimpeded passage of electromagnetic waves (such as radar signals). Composites, especially fiberglass, are highly transparent to these waves.
- **Durability and Resistance:** Composites provide resistance to environmental challenges such as extreme temperatures, UV exposure, and corrosion, making them suitable for harsh airborne environments.
- **Design Flexibility:** The manufacturing process of composites allows for complex shapes and tailored properties, which is beneficial for radomes that need to be aerodynamically efficient.

The theoretical analysis section covered the principles of electromagnetic wave transmission through composite materials, particularly for radomes. The speaker explained how the material properties, such as dielectric constant and loss tangent, affect the transmission of electromagnetic waves. The focus was on the need to ensure that the composite material used in radomes does not significantly attenuate radar signals while providing adequate structural protection. The theoretical models discussed included the electromagnetic wave propagation theory and how it applies to the design and material selection for radomes.

The lecture continued with a detailed discussion on the experimental techniques and fabrication methodologies used to manufacture composite radomes:

- **Fabrication Process:** The fabrication of composite radomes typically involves processes such as hand layup, filament winding, and resin transfer molding (RTM). These methods ensure that the composite material is properly aligned and cured for optimal mechanical and electromagnetic performance.
- **Curing Process:** The curing process was explained as critical to ensuring that the composite material achieves its desired mechanical properties, including strength, stiffness, and thermal resistance.
- **Characterization Techniques:** The speaker outlined the primary experimental techniques used for testing and characterizing composite radomes. These included:
    - **Microwave and Radar Transmission Tests:** To assess how well the radome material allows electromagnetic waves to pass through.
    - **Mechanical Testing:** To evaluate the material's tensile strength, compressive strength, and impact resistance.
    - **Thermal Cycling:** To test the radome's ability to withstand extreme temperature variations during airborne operations.
    - **Environmental Testing:** To simulate exposure to UV radiation, moisture, and other environmental factors.

The experimental characterization of composite radomes was a key focus of the lecture. The speaker discussed various techniques for testing the mechanical and electromagnetic properties of composites in the context of radomes:

- **Electromagnetic Performance:** The primary goal is to ensure that the composite material does not distort or attenuate electromagnetic signals. This is typically measured using radar cross-section (RCS) tests and transmission loss measurements.

- **Mechanical Performance:** Composites used in radomes must be able to withstand various mechanical stresses, including aerodynamic forces, impacts, and vibrations. Mechanical testing ensures the material is capable of maintaining its integrity during operation.
- **Environmental Resistance:** Composite radomes must also be tested for their ability to resist environmental degradation, such as UV degradation, moisture absorption, and temperature fluctuations. Accelerated aging tests are often used to simulate long-term exposure to these factors.

The speaker concluded by highlighting the various applications of composite radomes in airborne systems:

- **Aerospace:** Radomes are crucial components in aircraft for housing radar systems, enabling communication, navigation, and weather detection without compromising aerodynamic performance.
- **Unmanned Aerial Vehicles (UAVs):** Composites are also used in the design of UAV radomes, which need to be lightweight and durable for long-duration flights.
- **Missile Systems:** Radomes are used to protect missile guidance systems from environmental conditions while allowing radar signals to pass through.
- **Space Applications:** In some cases, composite radomes are used in satellites and spaceborne systems, where lightweight and durability are essential.

Conclusion:

The guest lecture provided a comprehensive understanding of composite radome characterization for airborne applications. The speaker emphasized the importance of material selection, fabrication methods, and experimental techniques in ensuring that composite radomes meet the stringent demands of aerospace and defense systems. Through a combination of theoretical analysis and experimental characterization, engineers are able to optimize composite radomes for maximum performance in various airborne and space applications. This lecture was highly informative, giving valuable insights into both the practical and theoretical aspects of composite radome design and characterization.