1. **State of the Art:**

This section summarizes the similar techniques used for the experimentation of the hybrid sandwich composites. The analytical and experimental approaches are used to resolve failures in the sandwich composites. The introduction to this section provides a brief overview of various types of face sheets selected and changes to the orientation/ loading effects on the structure, this helps the problem in understanding the ways to provide a solution, along with the effect of resin shrinkage on the structural properties. Also, highlight the possible areas of improvement for the

* 1. Design and Manufacturing of sandwich composites especially for partition walls:

The partition wall is a sandwich construction that is constructed to serve the purpose of bearing the flight loads and withstand the deflection/ deformation under certain conditions. The use of sandwich composites in aircrafts is done as it is a lightweight construction. This lightweight concept qualifies the sandwich composites to be applied at various locations in the aircrafts, specifically for the interior components. Various factors must be considered while using the sandwich materials like Honeycomb core and face sheets. The construction takes lot of efforts and quality for the assembly due to its critical requirements and various manufacturing styles and methods sometimes causes the irregularity in the structure, like the milling leads to the defective grooving of NOMEX honeycomb cores and this causes out of tolerance dimensions that further links to denting of face sheets due to lesser stiffness in the localized zone. Another condition includes the resin shrinkage during polymerisation reaction. The thickness of the face sheets plays a vital role in generating the necessary stiffness against the pressure loads during manufacturing. These topics are the part of current state of the art and involves a hybrid sandwich partition that must have a clean flush surface for the aircrafts/ airline industry for the aesthetic purposes, this criterion being very stringent makes the manufacturing process difficult and time consuming for achieving the good surface finish. In this context, various methods of manufacturing and topics related to the construction of sandwich panels will be discussed and will be related in a way to be use the methodology for the current issues in the industry.

Ein Bild, das Kompositmaterial, Im Haus, Boden, Werkzeug enthält.

Automatisch generierte Beschreibung

Figure 1 Hybrid sandwich composite partitions

* + 1. Sandwich composites in aircraft application:

Particularly in the aircraft sector, the advancement of modern engineering depends critically on the creation of new materials. Sandwich structured composites have drawn a lot of attention among these materials because of their outstanding stiffness-to---weight ratio, high strength-to---weight ratio, and great thermal insulation capacity (Krzyżak et al., 2016).Two thin exterior skins made of strong, durable materials enclose the light weight core of these composites. Their unique structure, which provides exceptional mechanical performance at low weight, makes them ideal for application in civil engineering, automotive, marine, and aviation.

This research project will examine existing techniques and applications to comprehend the properties of sandwich composites in various applications, including primary and secondary structures.

In sandwich composites, layer interactions are intended to increase structural efficiency. According to Gibson and Ashby (1997), the core absorbs shear stresses while the outer skins transmit loads such as compressive and flexural pressures. The thickness of the core of a sandwich panel greatly increases its stiffness, providing a major advantage over solid materials (Krzyżak et al., 2016). For example, a 4% increase in weight results in a roughly seven-fold increase in stiffness when the core thickness is doubled (Table 1)

|  |  |  |  |
| --- | --- | --- | --- |
| Property | Laminate (Skin) | Sandwich Structure | Thicker Sandwich Structure |
| Stiffness | 1 | 7 | 37 |
| Flexural Strength | 1 | 3.5 | 9.2 |
| Weight | 1 | 1.04 | 1.06 |

Table Stiffness - Weight comparison of composites

Sandwich composites could lose their integrity even with their benefits if delamination results from impact stresses (Krzyżak et al., 2016). Thus, maximising their performance calls for knowledge of the interactions among mechanical properties, manufacturing techniques, and material composition.

Manufacturing methods: The manufacturing technique applied determines most the quality of sandwich composites. Usually used are hand lay-up, press moulding, and autoclave curing. Any method has advantages and disadvantages.

Hand lay-up, in which resin and reinforcing materials are physically placed to a mould, is one widely used and cost technique. Still, this method occasionally yields air spaces, bulkier material (Krzyżak et al., 2016), and uneven resin dispersion.

Hand lay-up composites hence have more varied test results and worse mechanical quality than alternative methods.

By means of consistent pressure during curing, press moulding guarantees better resin dispersion and reduces defects including air bubbles (Krzyżak et al., 2016). This method improves consistency in the composite even if it may not eliminate all defects, especially in the skin-core contact. Press composites often demonstrate great compressive strengths even though they often delaminate under impact stress.

Mechanical aspects

Mechanical properties of sandwich composites depend on the kind of reinforcement, core material, and production procedure. Key criteria under review in research initiatives are compressive strength, flexural strength, and impact resistance.

Tests of compressive strength matching manufacturer criteria revealed that all panels obtained an average compressive strength of around 0.59 MPa (Krzyżak et al., 2016). Because their resin content in loosely distributed fibres was higher, composites reinforced with mats often showed higher modulus values than those with textiles.

Because of their thicker outer layers and multidirectional fibre orientation (Krzyżak et al., 2016), flexural tests revealed that composites including mat reinforcements had the highest flexural strength. Improved flexural performance in autoclave-cured composites also indicated the significance of under control manufacturing environments.

Using Charpy's approach, impact testing revealed the better impact resistance of autoclave-cured composites—especially those reinforced with low-basis-weight fabrics—Krzyżak et al., 2016 noted. This better performance resulted from even resin dispersion and robust skin-core adhesion attained by autoclaving.

Understanding the failure mechanisms of sandwich composites is crucial for enhancing their durability and reliability. Common failure modes include:

1. Delamination occurs when the adhesive bond between the skin and core weakens under stress. Hand-layup and press-moulded composites are particularly vulnerable to delamination due to imperfect interfaces (Krzyżak et al., 2016).
2. Core shear failure arises from excessive shear stresses within the core material. This mode of failure is prevalent in composites subjected to bending loads, where the core experiences high deformation near the load application point (Krzyżak et al., 2016).
3. Skin fracture occurs when the outer layer cannot withstand applied loads, leading to cracking or complete separation. Autoclave-cured composites tend to experience localized skin fractures rather than extensive delamination, underscoring their robustness under impact (Krzyżak et al., 2016).

Comparative Analysis of Manufacturing Techniques

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Hand Lay-Up | Press Method | Autoclave Curing |
| Cost | Low | Moderate | High |
| Consistency | Poor | Good | Excellent |
| Mechanical Properties | Lower | Improved | Superior |
| Surface Quality | Rough | Smooth | Highly Uniform |
| Suitability for Aeronautics | Limited | Suitable | Ideal |

While hand lay-up remains popular for prototyping and low-cost applications, the press method and autoclave curing are preferred for critical aerospace components requiring high precision and reliability.

Future Directions

Research into sandwich composites continues to focus on improving their mechanical properties, reducing manufacturing costs, and addressing environmental concerns. Potential avenues for exploration include:

1. Developing lightweight cores with enhanced shear strength, such as nanocellulose or graphene-enhanced foams, could further improve the performance of sandwich composites.
2. Incorporating high-performance fibers like carbon nanotubes or basalt fibers into the skins could elevate the overall strength and stiffness of the composites.
3. Transitioning to eco-friendly resins and energy-efficient curing processes would reduce the environmental footprint of sandwich composite production.

Conclusion

Sandwich structured composites represent a transformative advancement in material science, offering unparalleled performance for lightweight structural applications. Their success in aeronautics hinges on the careful selection of materials, optimization of manufacturing processes, and thorough evaluation of mechanical properties. This literature review underscores the significance of adopting rigorous quality control measures and innovative technologies to unlock the full potential of sandwich composites in aerospace engineering. Future research should prioritize sustainability, affordability, and scalability to ensure their continued relevance in an evolving industry landscape.

* + 1. **Understanding the effect of manufacturing methods on sandwich panels mechanical properties**
    2. **Variation of the face sheets for structural stiffness**
    3. **Experimental Validation of Co-Cure Process of Honeycomb Sandwich Structures**
    4. **Experimental Validation of Mould Cavity and Core Design in Compression Moulding**
    5. **Investigation of the Cure Process for Thick Composite Sandwich Panels**
    6. **Effect of Curing Agent Type on Curing Reaction Kinetics of Epoxy Resin**
    7. **Mechanical responses of a composite sandwich structure with Nomex honeycomb core**
    8. **Machinability of Nomex honeycomb**

References:

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