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Honeycomb Wrap Paper Panel Structure

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ABSTRACT: Aero-engine developers focus more on increasing the efficiency of the engine. When it comes to efficiency the most effective factors that are to be considered are Weight, fuel consumption, working temperature, etc. As the aero-engine works at a higher temperature, the materials that are used in it have to withstand the higher temperatures. The best solution for increasing efficiency is sealing. The labyrinth seal is used to reduce the pressure and also acts as a cooling interface to the engine parts. The abradable structures are integrated into labyrinth seals. Those surfaces are coated with composite fabrication or substrates that are coated with sacrificial materials. Those sacrificial Materials are Honeycomb materials. Honeycomb material is lightweight in a design criterion and has excellent fatigue resistance. In this review paper the honeycomb's origin, manufacturing, and a few mechanical properties are explained.

I. INTRODUCTION

Honeycomb comprises a variety of open cells, framed from extremely slight sheets of material attached. The use of honeycomb in aero-engine applications is increasing day by day because of its properties like lightweight, good fatigue resistance, and low cost. The honeycomb material is made up of Hastelloy-X and Haynes 214 which are alloys of Inconel 718. There are nickel-based superalloys that are good at high temperatures. They are cheap at cost, so economically it is good to use. The use of honeycomb in the aero-engine will increase the life span of engine parts and will give good efficiency to the engine.[1] Honeycomb showcase is a quick and as yet developing business sector that offers different materials for any utilization. As it were Nomex honeycomb showcase is relied upon to collect $383.3 million by 2021 and register a CAGR (compound yearly development pace) of 8.5% somewhere in the range of 2016 and 2021[3]. Face sheets can be made of metals (aluminum, hardened steel), composites strengthened with carbon fibers, glass filaments or aramid strands, plastics, wood, or container [2, 4] A core can be utilized: foam, honeycomb, or normal materials like balsa wood or plug. Foam materials can be made up of plastics which will be like PVC, PU, PE, PS, PES, PET, PMI, PEI, and so forth.[4] It is additionally conceivable to utilize metals as foam however that isn't well known because foams have lower quality than honeycombs and lower work temperature (foams: > 180°C, honeycombs: > 250°C). They are utilized in components working on low loads however for the most part as an isolating panel. Honeycomb materials establish the greatest gathering of core materials utilized in sandwich structures. They can be utilized in the type of metallic and non-metallic honeycomb. From metallic the frequent use is aluminum (3003, 5052, 5056), which can be applied in structures working in temperatures up to 180°C.

Infrequently metallic honeycomb is produced using steel (17-PH, 316L, 347), titanium (6Al-4V, 6Al-2Sn-4Zr-2Mo), lead, or copper. Most regularly they are produced using non- metallic materials. Those could be composite materials strengthened by aramid fiber (Kevlar, Nomex), carbon fiber, glass fiber, and plastics (PVC, PET, PEI) [2,4,5, 6]

Honeycomb core materials are used in different application parts like driving edges, following edges, folds, spoilers, cowlings, fuselage, and components inside the plane (floors, roofs, sideboards). Moreover, in the helicopter industry, they can be utilized as the fundamental and tail rotor cutting edges.

Like in aeronautics, in the cosmonautic industry, mass is a significant boundary. Hence sandwich panels are so mainstream there. They are utilized in numerous vehicles as folds, outer boards of the body, driving edges, radar covers, in telescopes, drones, radio wires, and space stations [4]. Sandwich materials are generally utilized in the marine industry, for Example in vessels, ships, yachts, speedboats building, or as components of moors in marinas. They are typically utilized in the insides of boats as a body, hatches, applauds, stages, and so on [4, 7, 8].

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II. METHODOLOGY

Manufacturing the honeycomb can be done in different ways, depending on the application of the use. Honeycomb can be manufactured in five different ways.

1. Adhesive bonding: almost 95% of the honeycomb is made by adhesive bonding. The highest temperature adhesive-bonded nodes can withstand is about 750 °F (399°C)

2. Brazing: Brazing is an application of the joining process, which joins the material above the temperature of 800°F (427°C). Generally used for high-temperature applications.

3. Thermal Fusion: The highest temperature for the nodes to withstand is about 400°F (204°C)
4. Resistance Welding: it is also a high-temperature process for the materials that withstand the temperature of 1825°F(996°C)

5. Diffusion Bonding: It is also a joining process where the surface is heated in the furnace to a certain temperature of 1750°F (800°C)

Two basic techniques are used to convert the sheet material into honeycomb

(i) Expansion Process: In this process, both metallic cores and non-metallic cores can be formed. However, there are slight changes in both methods because plastic deformation of metals is permanent after a certain elasticity but in non-metallic cores the plastic deformation is temporary. First, the foil sheets are applied by a corrosive resistance coating and then adhesive lines are printed on the sheets for the expansion process. Then the honeycomb surface is cut into required thickness slices and then expanded to a certain elasticity. Whereas in the non-metallic core after the expansion it is placed in the rack and then dipped in the resin which is hot set in the oven. The dipping cycle is repeated until the desired density is obtained. Generally, the dipping cycle will be 3 to 4 cycles.[5]

(ii) Corrugation Method: It is the original technique used to fabricate the honeycomb core for making higher density. First, the foil sheet is passed to the corrugated rolls where it becomes the corrugated sheets then the adhesive coating is applied to it. After that, it is stacked and cured in an oven. Only a little pressure is applied on the sheet so the total weight of the honeycomb core is 10% of the node adhesive. Where in the expansion process it is about 1% or less of the node adhesive because a lot of pressure is applied to it. Instead of using adhesives in the nodes for high-temperature materials, we can use techniques like Brazing, diffusion bonding, or spot welding.[5]

III. LITERATURE REVIEW

- **S. N. Abhinav et al.** Aero-engine developers focus more on increasing the efficiency of the engine. When it comes to efficiency the most effective factors that are to be considered are Weight, fuel consumption, working temperature, etc. As the aero-engine works at a higher temperature, the materials that are used in it have to withstand the higher temperatures. The best solution for increasing efficiency is sealing. The labyrinth seal is used to reduce the pressure and also acts as a cooling interface to the engine parts. The abradable structures are integrated into labyrinth seals. Those surfaces are coated with composite fabrication or substrates that a recoated with sacrificial materials. Those sacrificial Materials are Honeycomb materials. Honeycomb material is lightweight in a design criterion and has excellent fatigue resistance.

- **B Castanie et al.** Sandwich structures exhibit static properties such as high stiffness-to-weight ratio and high buckling loads which are of great importance in the aeronautics field. Nevertheless, the current applications on commercial airplanes remain mainly limited to secondary structures like control surfaces or floor panels. In the field of helicopters where stress levels are lower, full sandwich structures are already in flight. One of the main limitations is linked to a lack of knowledge of the effects induced by impact. **S.**

- **Chang QI et al.** Honeycombs are typical cellular materials with two-dimensional arrays of unit cells in in-plane and parallel stack in the out-of-plane direction, characterizing a periodic topology assignment. Due to the interconnected network of the unit cells filling the internal space, honeycombs have higher porosity and lower

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mass density than their matrix materials, thus resulting in high specific stiffness/strength and specific energy absorption.

- **Marcel Oettingeretal**. Shroud cavities in aero engines are typically formed by a labyrinth seal between the rotating turbine shroud and the stationary casing wall. To mitigate rub-in and reduce weight, the casing often features honeycomb structures above the rotor seal fins. In this paper, the aerodynamic performance of such honeycomb structures is experimentally investigated using a rotating test rig featuring both smooth and honeycomb-tapered casing walls. Measurements show that the discharge coefficient decreases for the honeycomb configuration while losses and subsequent windage heating of the flow increase. A variation in rotational speed reveals additional sensitivities to the local flow field in the swirl chamber. Numerical simulations are conducted and validated using the experiments.

IV. PROPERTIES

The wide utilization of these materials has made a lot of regular use daily. These days sandwich materials assume a significant job in numerous ventures and regular day-to-day existence. Of all the previously mentioned kinds of cores, honeycomb cores are the most normally and broadly utilized. To be certain that composite material meets the desires, it must be altogether examined before it is guaranteed. Each material has its particular properties and based on them it is planned to be utilized in a different application. Sandwich materials test strategies depend on two fundamental classes: mechanical tests and physicochemical tests. These days, a lot of tests exist, on how to evaluate the properties of composite materials. It very well may be the American Section of the International Association for Testing Materials principles (ASTM), global principles (ISO), United States military guidelines (MIL-STD), aviation material norms (AMS), and own guidelines of the greatest creation organizations, for example, Boeing (BMS), McDonnell Douglas (MMS) and so forth [11-14]

V. CONCLUSION

Honeycomb materials are widely used in the applications of aerospace and aircraft engines. The manufacturing honeycomb should be done very carefully to reduce the failures. It is always best to use an adhesive that is temperature-cured as room-temperature adhesives will normally creep more than elevated-cured adhesives. Stress raisers will not become a factor if the node attachment is bonded properly. The honeycomb face sheets will take the bending momentum(one skin will take compression and the other will take tension) and the core will bear the shear loads. The weight of the honeycomb will be mostly of the weight of the core material. The weight of the honeycomb will be mostly of the weight of the core material. We use very thin face sheets as their weight will be 1% or less of the honeycomb core. Most of the material that is used in aircraft is the honeycomb.

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