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University of Stuttgart
Institute of Aircraft Design

DIEHL
Aviation

NOVEL COMPOSITE SANDWICH STRUCTURES WITH INTEGRATED VACUUM INSULATION PANELS

23rd International Conference on Composite Materials (ICCM23)

30 July – 4 August 2023

Vakhtang Latsuzbaya

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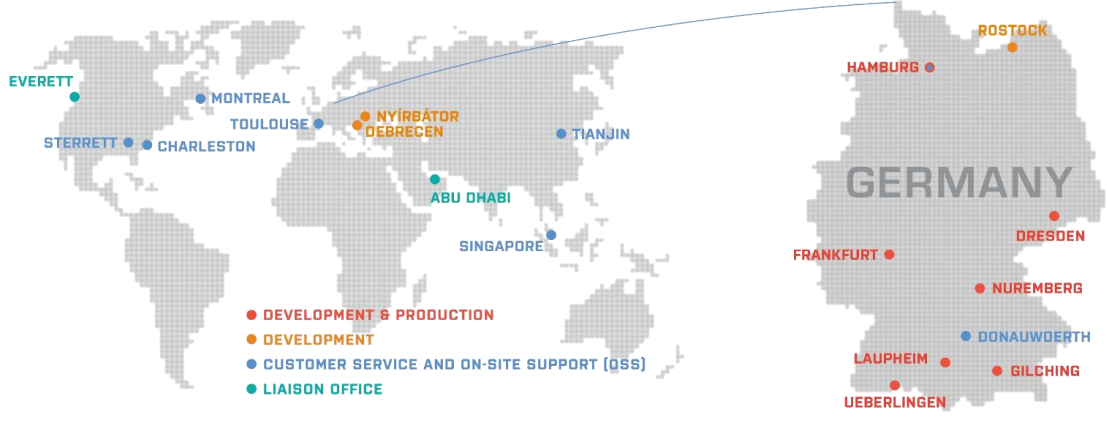
1. DIEHL AVIATION

Cabin Interiors:

- Floor-to-Floor (sidewalls, ceilings, overhead stowage etc.)
- Crew-Rest Compartments
- Air Distribution
- Galley
- Lavatory
- General Cabin Equipment

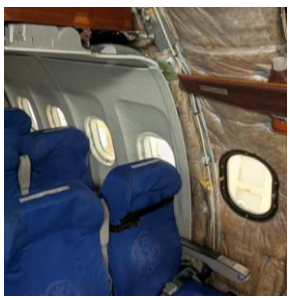


2. OBJECT AND MOTIVATION

Passengers of commercial aircrafts are spending an increasing amount of time in the aircraft cabin during travel. Therefore, they pay more attention to the **comfort of the cabin**. In order to achieve a satisfied passenger experience, the aircraft industry is seeking to improve the cabin comfort continuously. Some of the main factors that affect passenger comfort are **cabin climate, noise and space**. With the intention of **space increase** and simultaneously **improvement of thermal and acoustic situation** in the aircraft cabin, the search for better insulation materials led to **Vacuum Insulation Panels (VIP)**.

BEFORE

Thermal conductivity **λ = 40-65 mW/m·K**



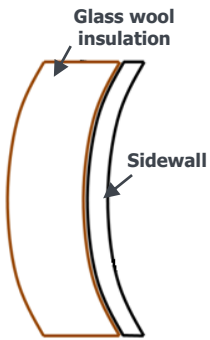


Figure 1 – Example of a sidewall with a conventional secondary insulation

AFTER

Thermal conductivity **λ = 10 mW/m·K**

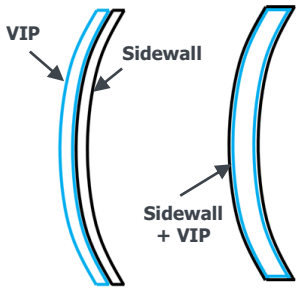


Figure 2 - Schematic representation of two types of structure proposals for new interior panels

Figure 3 – Sidewall with attached Vacuum Insulation Panel

2. OBJECT AND MOTIVATION

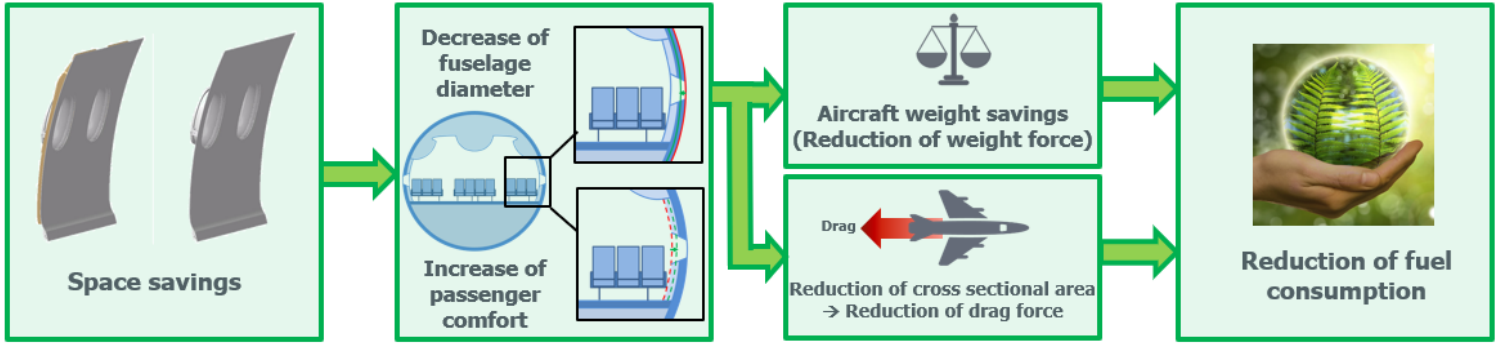


Figure 4 – Potentials of the new interior panels with integrated VIP

2. OBJECT AND MOTIVATION

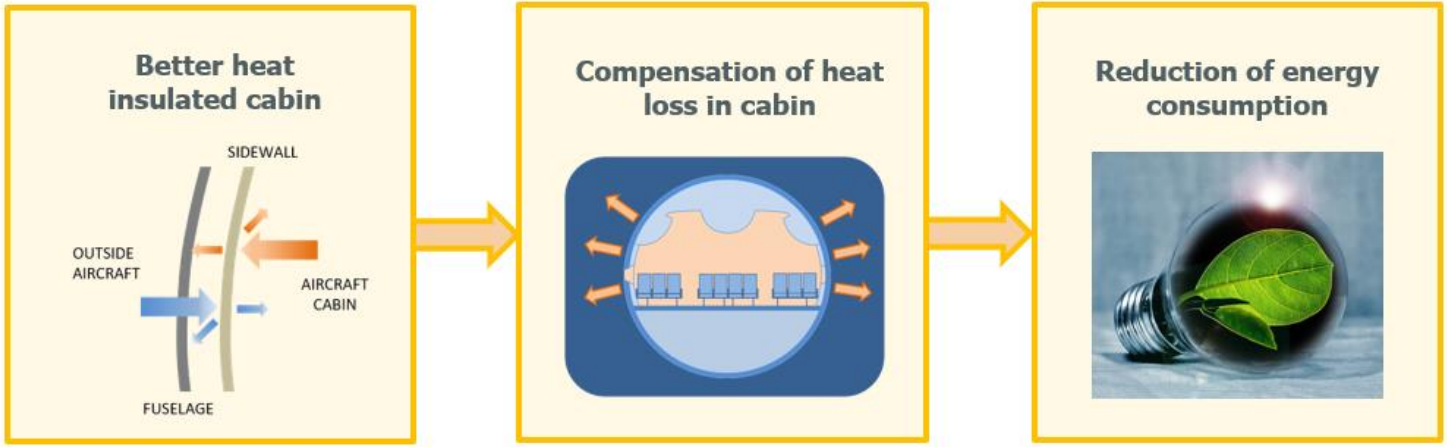


Figure 5 – Potentials of the new interior panels with integrated VIP

2. OBJECT AND MOTIVATION

Application in aircraft cabin:

- Lining panels (sidewall, door frame lining, door, ceiling)
- Crew Rest Compartments
- Monuments (galley, lavatory)
- Air ducting and others

Figure 6 – Sidewall panels, door frame lining and door, galley, Source: www.diehl.com/aviation

3. STATE OF THE ART – AIRCRAFT INSULATION

The **conventional insulation** in aircraft (primary and secondary) fills the space between the interior panels and fuselage of the aircraft [1]. Glass wool and thermoplastic foams (e.g. PI, PE) are commonly used as insulation material.

The thermal conductivity of such insulation is in the range of 30 – 50 mW/m·K.

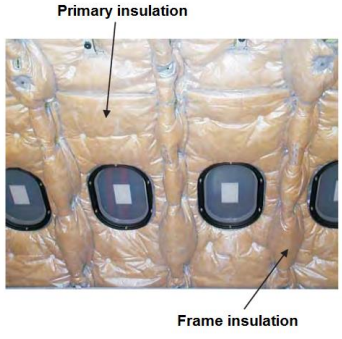


Figure 7 – Primary and frame insulation [1]

Figure 8 – Sidewall with secondary insulation on test rig [1]

Problem of conventional insulation:

Water accumulation in glass wool blankets, which causes following issues:

- "rain in the plain" effect
- increase in the total weight of the aircraft
- degradation of the thermal and acoustic properties of the glass wool packages
- corrosion of the primary structure
- growth of mold and bacteria

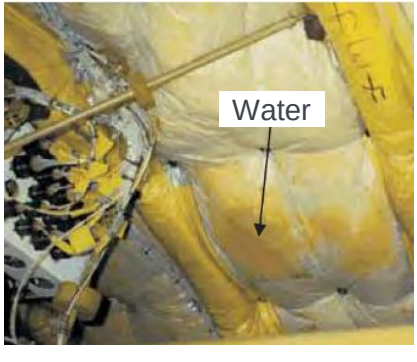


Figure 9 – Water accumulation in glass wool blankets [1]

3. STATE OF THE ART – INTERIOR PANEL

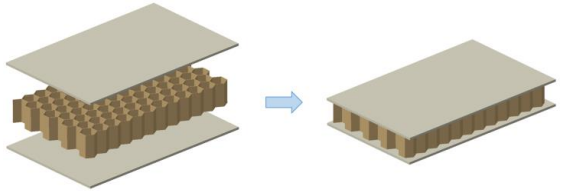


Figure 10 – Sandwich structure with honeycomb core

Conventional interior panels have a **honeycomb sandwich structure** covered by face sheets from both sides. This **structure** fully **meets requirements** regarding weight, mechanical loads, environmental conditions and flammability.

Acoustic and thermal insulation blankets are **attached** to the **rear side** of interior panels as secondary insulation.

The **production** of the insulation blankets and its **fixation** mean additional steps in the production chain, which is **time consuming** and requires an **enormous amount of manual work**.

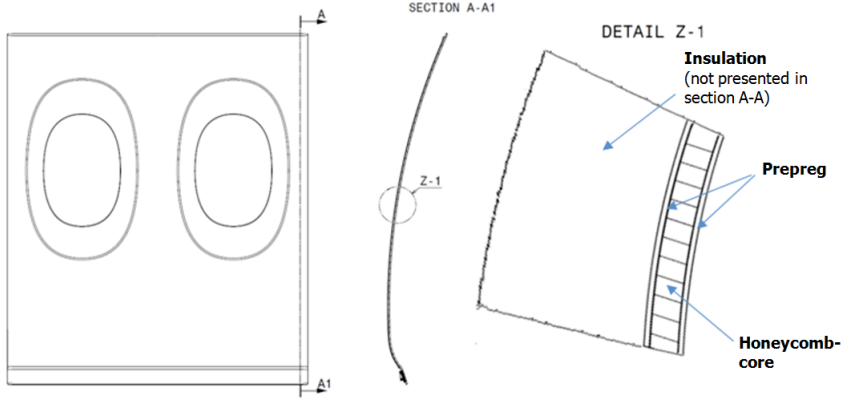


Figure 11 – Conventional interior panel on example of sidewall

3. STATE OF THE ART – VACUUM INSULATION PANEL

Vacuum Insulation Panel consists of:

- Fumed silica powder (core)
- High Barrier Foil (MF2)

Thermal conductivity = 4 mW/m·K

Applications:

- Fridges and freezers;
- Transport containers;
- Building industry.

Figure 12 – Vacuum insulation panel

Figure 13 – Various shapes of Vacuum insulation panel, Source: va-Q-tec AG

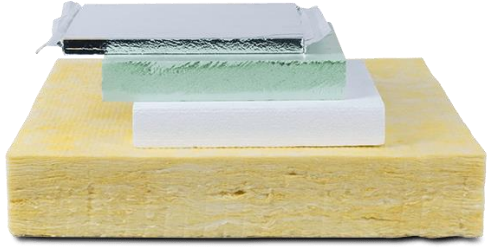


Figure 14 – Comparison of VIP to conventional materials (glass wool and foams), Source: ta-netzsch.com

4. STRUCTURE DEFINITION

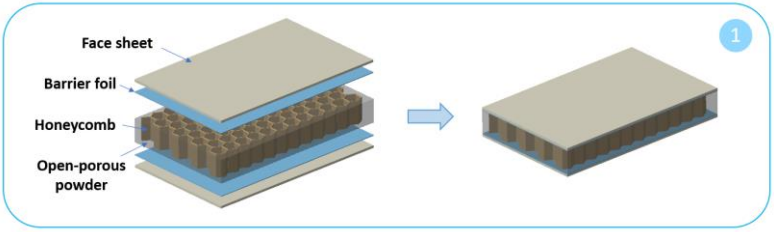
Four structure for new sandwich panels with integrated VIP were **proposed** based on theoretical analysis and analysis of requirements for interior panels and VIP.

Structure proposals

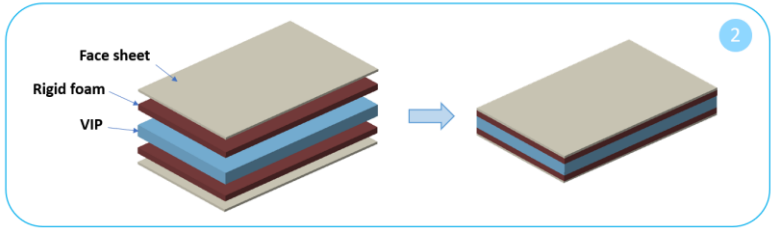
Sandwich panel layup that uses a VIP concept

Proposals with finished VIP panels which are added to modified sandwich panel layup

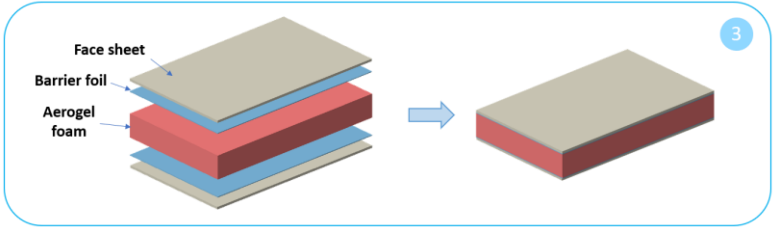
EVACUATED HONEYCOMB CORE



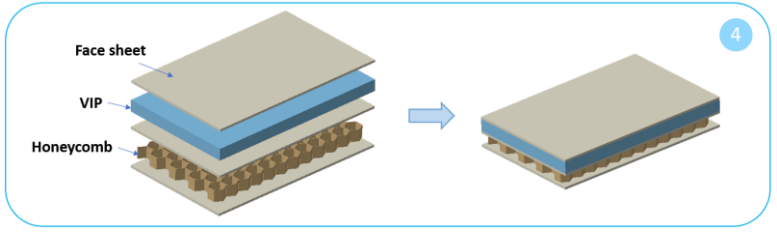
VIP COVERED BY FOAM AND PREPREG



EVACUATED AEROGEL CORE

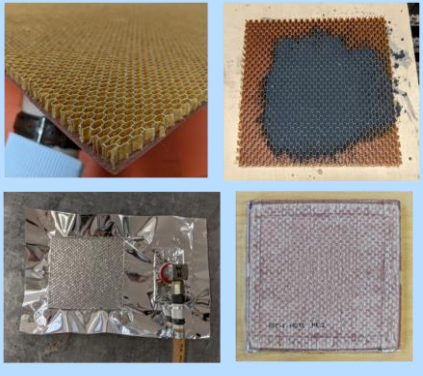


DOUBLE SANDWICH (VIP BONDED ON HONEYCOMB)

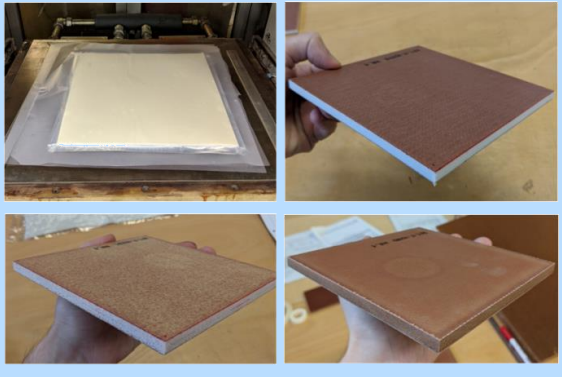


5. MANUFACTURING – FEASIBILITY STUDY

Feasibility study tests were performed for all four structure solutions in order to produce flat panels for thermal conductivity tests.

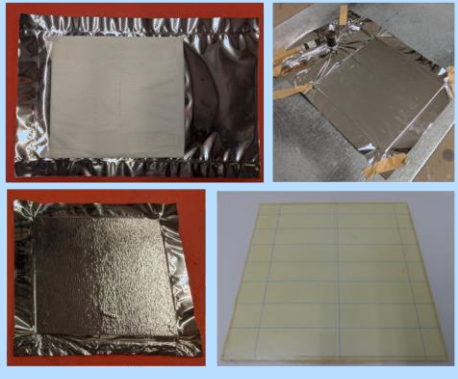


1. EVACUATED HONEYCOMB CORE



2. VIP COVERED BY FOAM* AND PREPREG

** PES, PVC & PMI foams*



3. EVACUATED AEROGEL CORE

4. DOUBLE SANDWICH (VIP BONDED ON HONEYCOMB CORE)

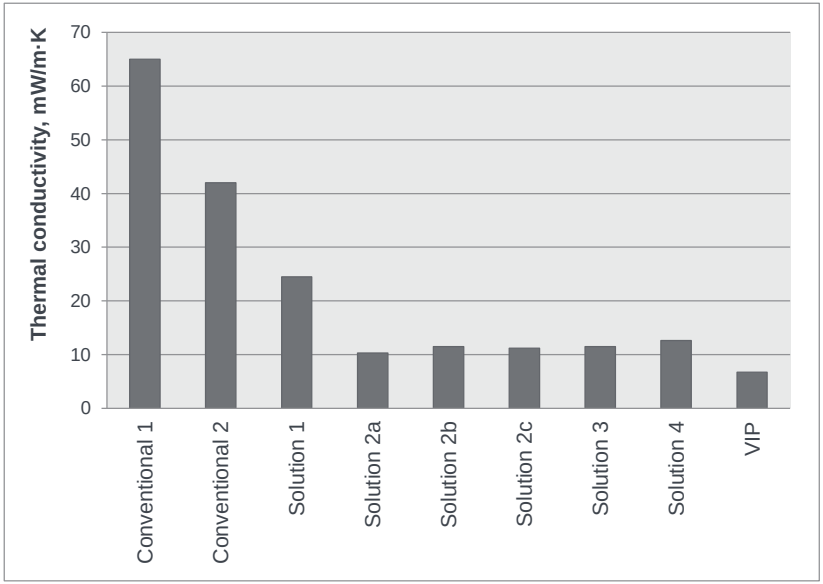
Result:

- evacuation of proposals 1 and 3 is possible;
- good surface quality;
- good bonding between core and face sheets;
- structure solutions have robust structure;
- all solutions are feasible.

6. THERMAL CONDUCTIVITY

All proposals were tested[1] for thermal conductivity. Following test results were obtained:

Proposal	Description	Thermal conductivity, mW/m·K
Conventional panel 1	Honeycomb panel w/o insulation	65
Conventional panel 2	Honeycomb with insulation	42
Solution 1	Honeycomb + Silica Powder (evacuated)	24,5
Solution 2a	VIP + PES Foam	10,3
Solution 2b	VIP + PVC Foam	11,5
Solution 2c	VIP + PMI Foam	11,2
Solution 3	PU Aerogel foam (evacuated)	11,5
Solution 4	Double sandwich (Honeycomb + VIP)	12,6
VIP	Sub component for proposals 2 and 4	6,7



Results: the new solutions showed a big difference in thermal properties in comparison to conventional structures. The thermal conductivity of **new structures** is **lower by the factor of 3-6**. Even lower values can be achieved with the relevant modifications.

[1]*Thermal conductivity of the panels was determined by TLP 300-DTX apparatus (Guarded Hot Plate) in accordance with the international standard ISO 8302.*

7. CONCLUSION AND OUTLOOK

- In this research project the **integration** of **highly efficient insulation VIP** into cabin interior panels was **investigated**;
- **Four structure solutions** were proposed for further feasibility study tests;
- The experiments demonstrated that **all new solutions** can be **manufactured**;
- The **thermal conductivity** of new structures is **lower by the factor of 3-6** in comparison to conventional solutions;

- **Further investigations** for vacuum maintaining, mechanical properties, acoustics, fire properties, manufacturing of curved panels and others are **on going**.
- Besides the cabin interiors for aircrafts, the new sandwich structures are also **highly attractive** for application such as **urban air mobility** (UAM), **trains**, **recreational vehicles** (RV), **caravans** and **transport containers**.

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- N. Andresen from Fraunhofer Institute for Building Physics IBP;
- and other persons.

REFERENCES

[1] Mario Wörner, Wärme- und Stofftransport in einer Flugzeugkabine unter besonderer Berücksichtigung des Feuchtetransportes, Aufl. - Göttingen : Cuvillier, 2006;
[2] Federal Aviation Administration (FAA), Aircraft Thermal/Acoustic Insulation Materials - Functions and Requirements, viewed 09.06.2020, https://www.fire.tc.faa.gov/pdf/insulate.pdf.

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Thank you!

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