Combining aerogels with honeycombs – a new stiff and flexible superinsulation

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AEROGEL
Aerogels are nanostructured highly open-porous solid materials synthesized by sol-gel process.

HONEYCOMB
Cellular solid material with different cell size and cell shape.

COMPOSITE
Honeycomb filled with flexible aerogel

Motivation
We propose to combine aramid honeycombs with organic resorcinol – formaldehyde aerogels to manufacture a new types of advanced insulation materials:
- Low thermal conductivity
- Low weight
- Adjustable mechanical properties: stiff or flexible
- Non-toxic, non-fuming.

Synthesis

Flexible Resorcinol-Formaldehyde (RF) aerogel
Resorcinol : Water = 0.008
Resorcinol : Formaldehyde 37% = 0.5
Resorcinol : Sodium carbonate = 50
pH = 5.6; stirring time 60 Min
Gelation and aging 7 days at 80°C
Washing with acetone and supercritical drying

Hard Resorcinol – Formaldehyde (RF) aerogel
Resorcinol : Water = 0.019
Resorcinol : Formaldehyde 24% = 0.5
Resorcinol : Sodium carbonate = 200
pH = 6.5; stirring time 30 Min
Gelation and aging 7 days at 80°C
Washing with acetone and supercritical drying

Results and Conclusion
Before test          20%  compression
Formation of cracks during compression in the middle of cells approves a sufficient contact between both materials.

<table>
<thead>
<tr>
<th>Material</th>
<th>Thermal Conductivity, W/mK</th>
<th>Young’s Modulus, MPa</th>
<th>Density, g/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aramid honeycomb</td>
<td>0.060</td>
<td>0.025</td>
<td>0.03</td>
</tr>
<tr>
<td>Hard RF aerogel</td>
<td>0.008</td>
<td>0.65</td>
<td>0.22</td>
</tr>
<tr>
<td>Flexible RF aerogel</td>
<td>0.037</td>
<td>0.01</td>
<td>0.06</td>
</tr>
<tr>
<td>Composite with hard RF aerogel</td>
<td>0.030</td>
<td>1.58</td>
<td>0.11</td>
</tr>
<tr>
<td>Composite with flexible RF aerogel</td>
<td>0.031</td>
<td>0.13</td>
<td>13.5</td>
</tr>
</tbody>
</table>

The filling of cells with aerogel changes the yielding of the honeycombs and increases the Young’s modulus.

Summary
- Reduced thermal conductivity
- Improved mechanical properties
- Sufficient, continuous contact between aerogel and honeycomb
- Non-toxic, non-fuming, light insulating material