Adhesively Bonded structures

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Joining
In the most general sense, joining is the act or process of putting or bringing things together to make them continuous or to form a unit.

Joining was undoubtedly one of the first, if not the first, manufacturing technology.

With the passage of time, the need for and benefits of joining have not abated; they have grown.

An assembly is a collection of manufactured parts, brought together by joining to perform one or more than one primary function.
INTRODUCTION

Usually, assemblies must perform multiple functions, albeit with one function generally being primary and the others being secondary.

Thus, the joints in assemblies must also support multiple functions.

For example, soldered joints in an electronic device:
- provides connectivity
- hold the electrical components together

joints are an extremely important and often critical aspect of any assembly or structure, and they are found in almost every structure.
For many structures, an ideal design would seemingly be one containing no joints.

since joints are generally a source of local weakness or excess weight, or both.

However, in practice, there are actually many reasons why a structure might need or be wanted to contain joints, sometimes by necessity and sometimes by preference.
There are four generally accepted goals of any design:

1. Functionality,
2. Manufacturability,
3. Cost,

The necessity of joining can be expressed based on the above design goals.

Reasons for Joining Structures and Materials:

1. Achieve Functionality
2. Facilitate Manufacturability
3. Minimize Costs
4. Provide Aesthetics
There are four generally accepted goals of any design:

1. **functionality,**
2. manufacturability,
3. cost,
4. aesthetics.
REASONS FOR JOINING MATERIALS AND STRUCTURES

special functionality
the right material to be used in the right place
(e.g., metals and glasses in an automobile’s windows)
Clearly, for something to be portable it either has to be small or has to be able to be disassembled and re-assembled.
There are four generally accepted goals of any design:

(1) **functionality,**
(2) **manufacturability,**
(3) **cost,**
(4) **aesthetics.**
Size or complexity or both joining is needed in large structures since:
- cannot be produced by any primary fabrication process, whether these structures are static or dynamic.
REASONS FOR JOINING MATERIALS AND STRUCTURES

to ship pre-fabricated parts to the site
There are four generally accepted goals of any design:

1. functionality,
2. manufacturability,
3. cost,
4. aesthetics.
Joining allows cost to be minimized by:

1. allowing **optimal material** selection and (versus forcing compromise);
2. allowing optimal material utilization (versus forcing scrap losses);
3. keeping the **weight of materials** needed to a minimum;
4. achieving functionality through large size and/or complex shape (without pressing primary processing limits);
5. sometimes (depending on the process) allowing automated assembly (to reduce labor cost and improve product consistency).
There are four generally accepted goals of any design:

1. functionality,
2. manufacturability,
3. cost,
4. aesthetics.
METHODS OF JOINING

- Periodic
- Linear
- Area

Important joining methods:

<table>
<thead>
<tr>
<th>Periodic</th>
<th>Linear</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivets</td>
<td>Welding</td>
<td>Soldering</td>
</tr>
<tr>
<td>Screws</td>
<td></td>
<td>Brazing</td>
</tr>
<tr>
<td>Spot Welding</td>
<td></td>
<td>Bonding</td>
</tr>
</tbody>
</table>

Welding          Soldering          Mechanical fastening          Adhesive bonding
## COMPARISON OF THE JOINING METHODS

<table>
<thead>
<tr>
<th>Joint Features</th>
<th>Welding</th>
<th>Brazing and soldering</th>
<th>Mechanical fastening</th>
<th>Adhesive bonding</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Permanence</strong></td>
<td>Permanent joints</td>
<td>Usually permanent (soldering may be nonpermanent)</td>
<td>Threaded fasteners permit disassembly</td>
<td>Permanent joints</td>
</tr>
<tr>
<td><strong>Stress distribution</strong></td>
<td>Local stress points in structure</td>
<td>Fairly good stress distribution</td>
<td>Points of high stress at fasteners</td>
<td>Good uniform load distribution over joint area</td>
</tr>
<tr>
<td><strong>Materials joined</strong></td>
<td>Generally limited to similar material groups</td>
<td>Some capability of joining dissimilar metals</td>
<td>Most forms and combinations of materials can be fastened</td>
<td>Ideal for joining most dissimilar materials</td>
</tr>
<tr>
<td><strong>Mechanical resistance</strong></td>
<td>Special provision often necessary to enhance fatigue resistance</td>
<td>Fairly good resistance to vibration</td>
<td>Special provision for fatigue and resistance to loosening at joints</td>
<td>Excellent fatigue properties. Electrical resistance reduces corrosion</td>
</tr>
<tr>
<td><strong>Temperature resistance</strong></td>
<td>Very high temperature resistance</td>
<td>Temperature resistance limited by filler metal</td>
<td>High temperature resistance</td>
<td>Poor resistance to elevated temperatures</td>
</tr>
<tr>
<td><strong>Appearance</strong></td>
<td>Joint appearance usually acceptable.</td>
<td>Good appearance joints</td>
<td>Surface discontinuities sometimes unacceptable</td>
<td>No surface marking. Joint almost invisible</td>
</tr>
<tr>
<td>Production Aspects</td>
<td>Welding</td>
<td>Brazing and soldering</td>
<td>Mechanical fastening</td>
<td>Adhesive bonding</td>
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<tr>
<td><strong>Joint preparation</strong></td>
<td>Little or none on thin material. Edge preparation for thick plates</td>
<td>Prefluxing often required</td>
<td>Hole preparation and often tapping for threaded fasteners</td>
<td>Cleaning often necessary</td>
</tr>
<tr>
<td><strong>Post-processing</strong></td>
<td>Heat transfer sometimes necessary</td>
<td>Corrosive fluxes must be cleaned off</td>
<td>Usually no post-processing — occasionally re-tightening in service</td>
<td>Not often required</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
<td>Relatively expensive, bulky and often required heavy power supply</td>
<td>Manual equipment cheap. Special furnaces and automatic unit expensive</td>
<td>Relatively cheap, portable and “on-site” assembly</td>
<td>Only large multi-feature, multi-component dispensers are expensive</td>
</tr>
<tr>
<td><strong>Consumables</strong></td>
<td>Wire, rods, etc., fairly cheap</td>
<td>Some special brazing fillers expensive. Soft solders cheap</td>
<td>Quite expensive</td>
<td>Structural adhesives somewhat expensive</td>
</tr>
<tr>
<td><strong>Production rate</strong></td>
<td>Can be very fast</td>
<td>Automatic processes quite fast</td>
<td>manual tightening slow. Mechanized tightening fairly rapid</td>
<td>Seconds to hours, according to type</td>
</tr>
<tr>
<td><strong>Quality assurance</strong></td>
<td>NDT methods applicable to most processes</td>
<td>Inspection difficult, particularly on soldered electrical joints</td>
<td>Reasonable confidence in torque control tightening</td>
<td>NDT methods limited</td>
</tr>
</tbody>
</table>


Advantages and Disadvantages of Adhesive Bonding
Theories of adhesion

Surface tension
Surface free energy
Theories of adhesion
ADHESIVELY BONDED JOINTS

(a) SLJ

(b) DLJ

(c) Joggle lap joint

(d) Beveled lap joint

(e) Butt joint

(f) 

(g) 

(h) 
ADHESIVELY BONDED JOINTS

(c) Fair - Fair
   Poor  Poor

(d) Good - Good
   Fair - Good

(e) Good - Good
   Good  Good

(f) Fair - Good
   Good - Poor

(i) Poor - Good
   Good - Poor

(j) Good - Good
   Fair - Good

(k) Good - Good
   Good - Fair