1
Introduction

1.1
Bonding as a Joining Process

Adhesive-bonding is assigned to the *materially joined* processes. Bonding processes serve the production of joints of materials of the same kind or of material combinations. The term "materially joined process", which also includes welding and soldering, derives from the fact that the bond occurs by a separately added material, that is

- the adhesive in the case of bonding,
- the welding additive material in the case of welding, and
- solder in the case of soldering.

In addition, there are

- *positive* joints, for example, folding, indented joining;
- *nonpositive* joints, for example, pressing, clamping, screwing, riveting (Figure 1.1).

1.2
Advantages and Disadvantages of Bonding

Compared to some of the joining processes depicted in Figure 1.1, bonding shows remarkable *advantages*:

- The adherends are not weakened by bores as it is the case, for example, when screwing and riveting. Thus power transmission is surface-related instead of spot-related (Figure 1.2).
- There adherends are not stressed by high temperatures, as in welding and, partly, even in soldering. Thus, thermally caused modifications of material properties are prevented, which enables heat-sensitive materials to be joined.
- Adhesive-bonding allows extremely different materials to be joined with themselves or with other materials while retaining their specific characteristics. In the latter case, it is possible to utilize the different advantageous properties for innovative composite structures.

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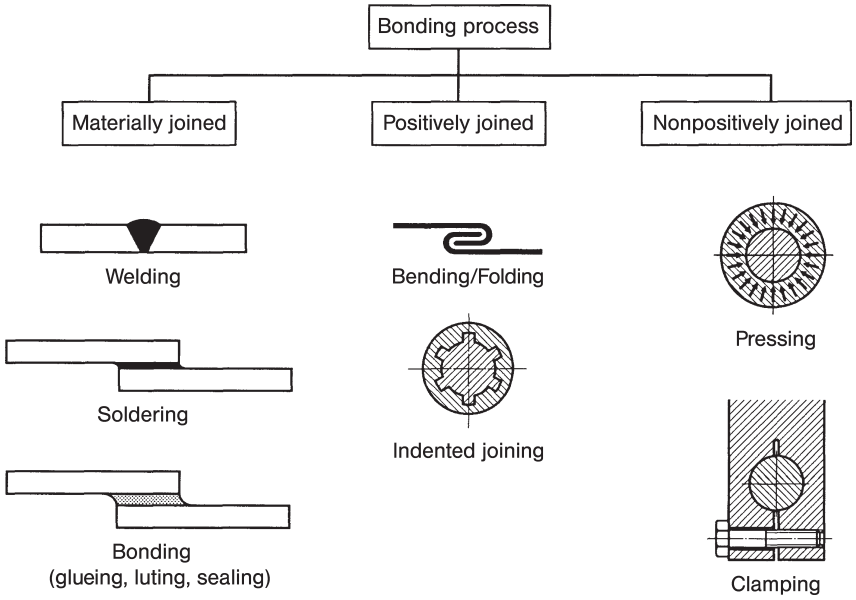

Figure 1.1 Classification of joining processes.

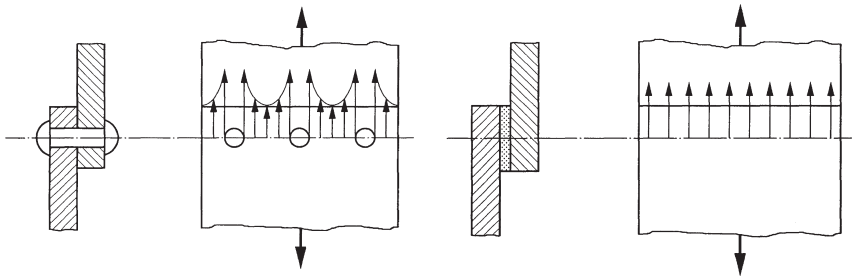

Figure 1.2 Power transmission in riveted (screwed) and bonded joints.

- Bonding as a joining process enables joints of very thin materials (< 500 µm). This procedure is particularly important for the manufacturing of lightweight constructions and the related weight reduction (*inter alia* in aerospace manufacturing). Furthermore, it is the basis of an extremely varied design of film-type laminates in the packaging industry.
- The combination of positive and nonpositive joining processes is important for the optimization of strength, stiffness and corrosion resistance, as the case may be (e.g., folding – bonding in car manufacturing), tightness (e.g., in screw, rivet and spot-welding constructions, shaft-to-collar connections and folds) (Figure 1.1 and 11.5).
- Compared to riveted or screwed connections homogeneous stress distribution when stress-loading (Figure 1.2).

However, these advantages are curtailed by the following *disadvantages:*

- The heat resistance of the adhesive layer is limited. Depending on the basic material of the adhesive, temperatures for continuous stress range between approximately 120 and 300 °C.
- Adhesive layers and their boundary layers towards the adherends' surfaces may be damaged by environmental impacts, such as humidity, which results in a reduction of strength.
- With a few exceptions (e.g., body-in-white manufacturing), the production of bonded joints requires surface treatment of the adherends as an additional production stage.
- In the production of bonded joints, the time required for the relevant reaction kinetics of curing has to be taken into consideration.
- The growing demand for recyclability of industrial products calls for respective design-engineering measures.
- The availability of nondestructive test methods is rather limited.

The essential difference between welding and soldering on the one hand, and bonding on the other hand is the structure of the additive material. Welding additives and solders consist of metals and metal alloys, respectively, which liquefy to a melted mass under the influence of heat (welding torch, soldering iron) and result in a joint after cooling down while integrating parts of the adherends. Adhesives, in comparison, consist of chemical compounds and structures on a basis different from that of metals. These relations are described in Chapter 2.

1.3
Terms and Definitions

Binding terms are a prerequisite to ensure quality-determining production flows in industrial processes. The following terms apply to the manufacturing system of "bonding":

1. Bonding: Joining of same or different materials under the application of adhesives.
2. Adhesive: Nonmetal, liquid, paste-like or even solid material, joining adherends by means of adhesion forces (surface adhesion) and cohesion forces (inner stability of the adhesive layer) (Chapter 6).
3. Adhesive layer: Adhesive layer between the adherends, set (cured) or still not set.
4. Boundary layer: Zone between adherends surface and adhesive layer where adhesion and bonding strengths are effective.
5. Glueline: Space between two adherend surfaces filled with an adhesive layer.
6. Adherend surface: The glued surface or surface to be glued of an adherend or a bonded joint.
7. Bonded joint: Joint of adherends, obtained by an adhesive.

8. Adherend: Body bonded or to be bonded to another body.
9. Setting, curing: Solidification of the liquid adhesive layer.
10. Structural bonding: Structural design with high strength and stiffness resp., with regular and favorable stress distribution (contrary: fixing bonding, e.g., in case of wallpaper) possible through bonding.

Figure 1.3 shows the structure of a single-lap bonded joint with the most important terms.

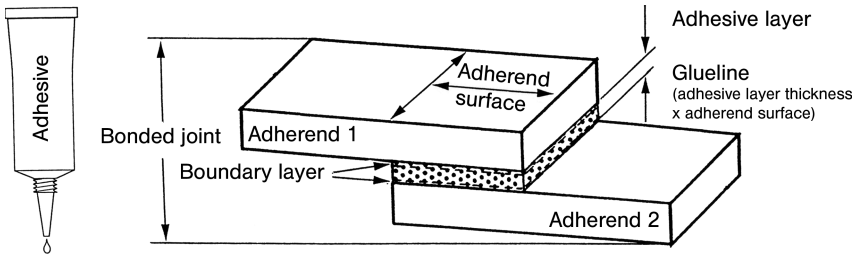

Figure 1.3 Adhesive terms.

Complementary literature to Chapter 1 – general overviews:
[A2, B5, C2, K1, L1, P3].