TALAT Lecture 4105

Combination of Joining Methods

16 pages, 19 figures

Basic Level

prepared by Lothar Budde, Universität-Gesamthochschule Paderborn

Objectives:

– to describe the combination of mechanical joining with adhesive bonding with respect to application criteria, productions considerations and resultant properties

Prerequisites:

– General mechanical engineering background
– TALAT lectures 4101 - 4104

Date of Issue: 1994

4105 Combination of Joining Methods

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Comparison of Functional Characteristics of Different Fastening Technologies

The functional characteristics of the different fastening technologies is important, since this enables us to choose the most appropriate joining technology for light constructions which are being developed and used increasingly.

A large number of the so-called "classical" fastening technologies currently in use fulfil these requirements only partly, making it necessary to use solutions which are a compromise (**Figure 4105.01.01**).

Joining Technology / Characteristics	Adhesive Joining	Spot Welding	Clinching	Riveting
Functional Characteristics	Load-Carrying Fixing Sealing Isolating Damping Equalising Good Fatigue Strength	Load-Carrying Fixing Elec. Conduct. Relatively Low Fatigue Strenght	Load-Carrying Fixing Elec. Conduct. Relatively Low Fatigue Strenght	Load-Carrying Fixing Elec. Conduct. Relatively Low Fatigue Strenght

Source: Budde

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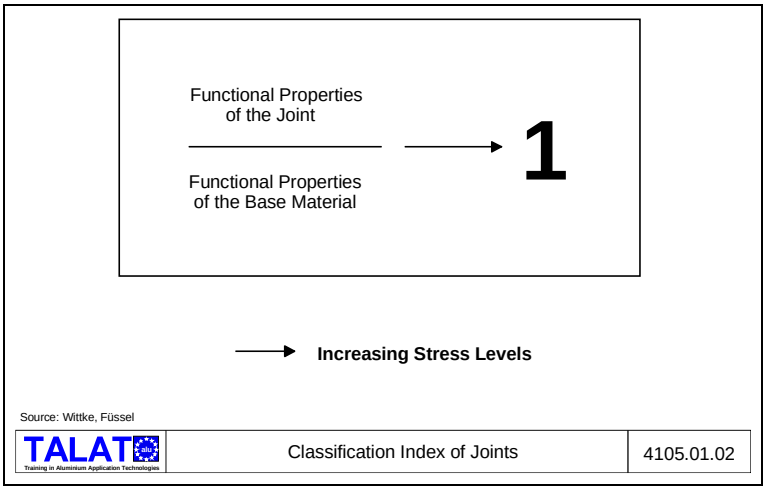
Classification Index of Joints

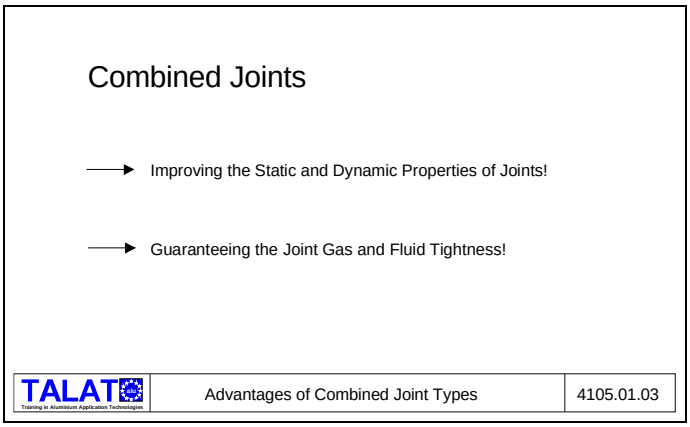
The joining technology used in light constructions should be such that the classification index of the joint, a value for the functional characteristics relative to the corresponding base material of the corresponding material combination, optimally approaches the limiting value of 1 (**Figure 4105.01.02)**.At increased stresses, the principles of force actions, the reduction of disadvantageous notch effects, the constancy of the material properties and the joint reliability become increasingly important.

A consequence of the above mentioned is that there is an increasing tendency to use aluminium for highly stressed constructions.



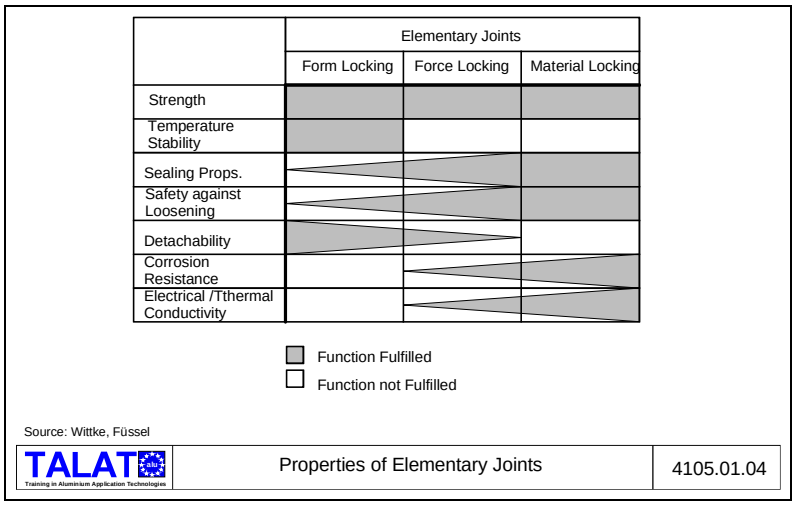
Advantages of Combined Joint Types

A combination of joint types can be used, among others, to take advantage of the specific material properties of aluminium, thus making it possible to optimise the joint quality, allow certain materials and material combinations to be joint and/or to simplify the fastening process. A combination of different joint types can be used either to improve the statical and dynamical properties of the joint or to guarantee leakproof joints (**Figure 4105.01.03**).



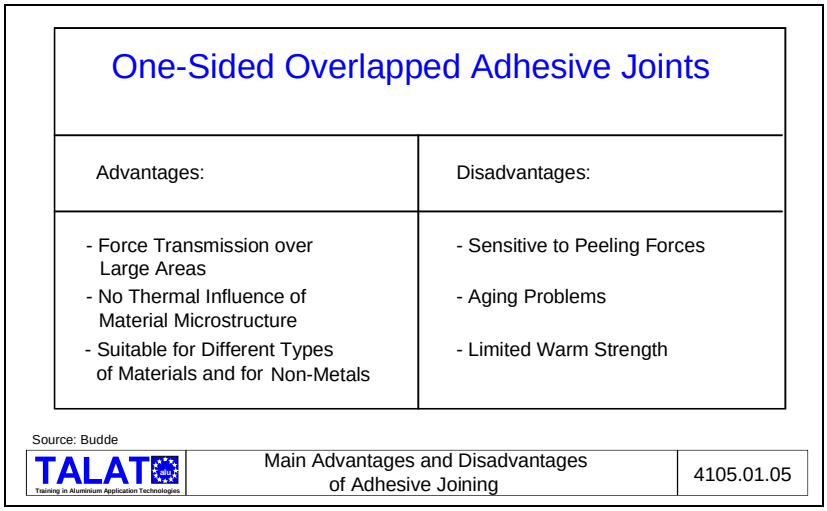
Properties of Elementary Joints

Depending on the load carrying capacity and the design of the light construction, the types of joints used may be of the material locking kind or of the force or shape locking type (**Figure 4105.01.04**). The choice of the elementary joints to be used in combination is based on the principle of elimination. According to this principle, those particular combinations of joints which do not fulfil any one out of a required list of criteria, are eliminated.



Main Advantages and Disadvantages of Adhesive Joining

Adhesive joining plays an important role in the design of ultralight constructions. The main advantages of adhesive joints are the transmission of forces over large areas and the possibility of joining different and non-metallic materials as well as material combinations. The disadvantage of adhesive joining is the fact that, as a rule, the components have to be held rigidly in a fixture during the hardening process. In addition to this, adhesive joints have a limited high-temperature strength (**Figure 4105.01.05**).



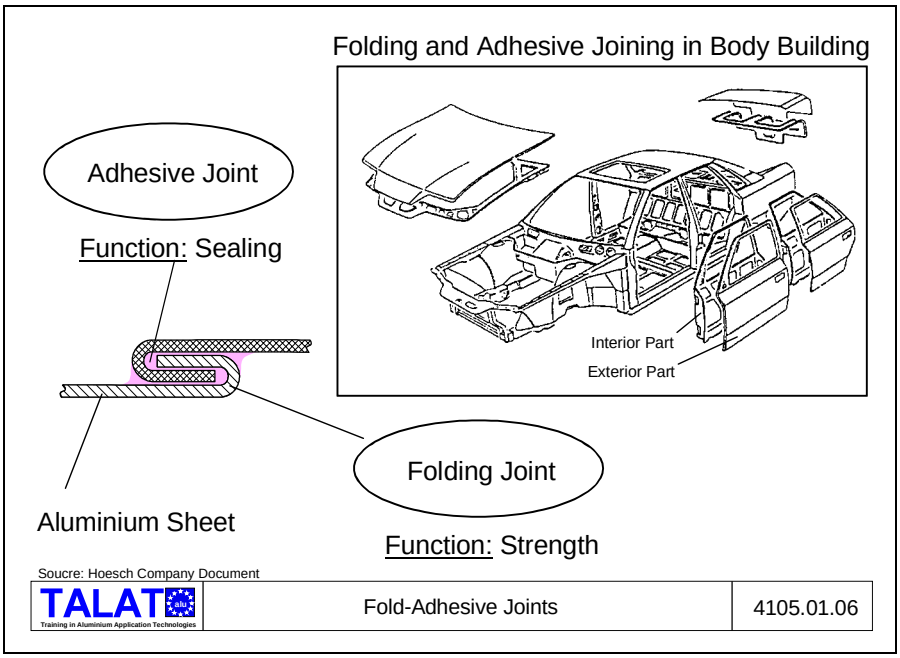
The specific disadvantages of adhesive joining can be compensated for by using a

combination of this material locking joint type with force and shape locking types of joints. Examples of such combined joints can be found in the automotive (mass production) and aircraft (small series production) industries.

Fold-Adhesive Joints

In the automotive industry, the combination of adhesive joining and folding can be used for fastening car-body parts. If applied properly, the folded and adhesively joint parts possess the combined advantages of both fastening technologies (**Figure 4105.01.06**).

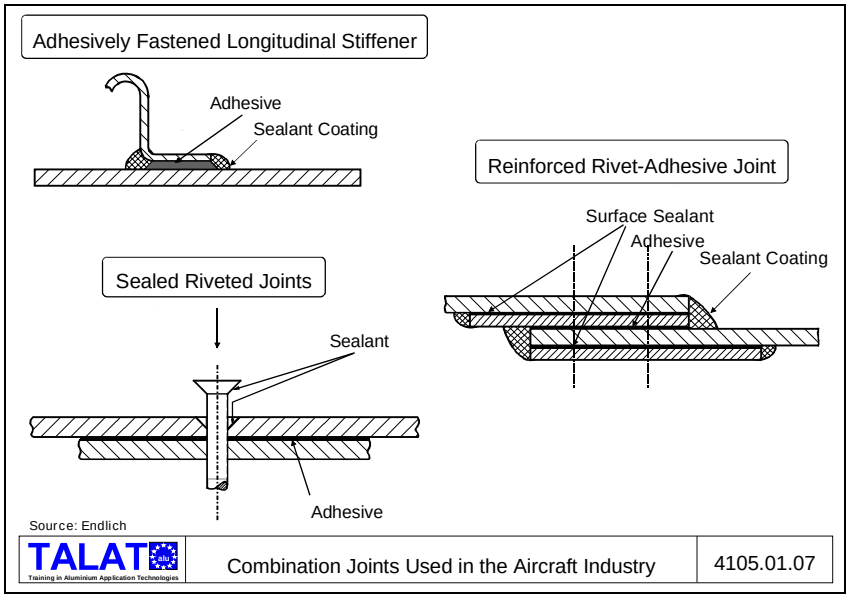
The main advantage of folded joints is that these can be loaded immediately, i.e., a rational production is possible. The surfaces of the folded joints produced remain smooth and clean. The additional use of adhesives in the fold leads to leakproof joints. At the same time, the adhesive used improves the damping characteristics of the whole aluminium construction.



Examples of Combined Joints Used in the Aircraft Industry

Some adhesive and sealed joints are prone to a deleterious ageing, especially if exposed to industrial atmosphere, water, solvents or aggressive chemicals.

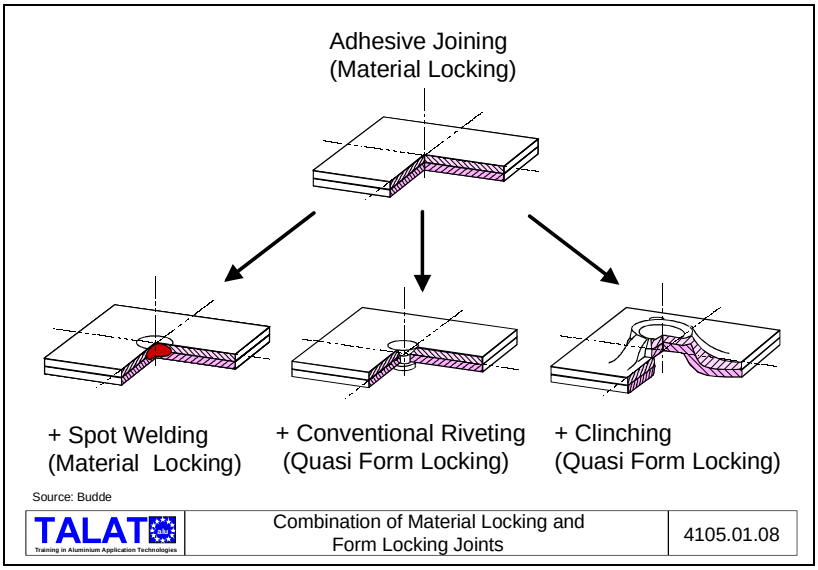
Examples of combined adhesive and sealed joints used in aircraft construction illustrate how this deleterious effect can be reduced by the judicious choice of adhesive and sealant, the long-time testing of the joints, a specific design as well as the application of protective layers on the surface of the adhesive and sealed joints (**Figure 4105.01.07**).



Combination of Material Locking and Form Locking Joints

Joints, consisting of a combination of both adhesive joining and locally active fastening methods, mostly use spot welding or mechanical joining methods like riveting and clinching. In the automotive industry, spot welding is used mainly to shorten production times in spite of the long hardening times of the adhesives. The combination of adhesive and riveted joints is used primarily in the aircraft industry for parts subject to dynamic loading (**Figure 4105.01.08**).

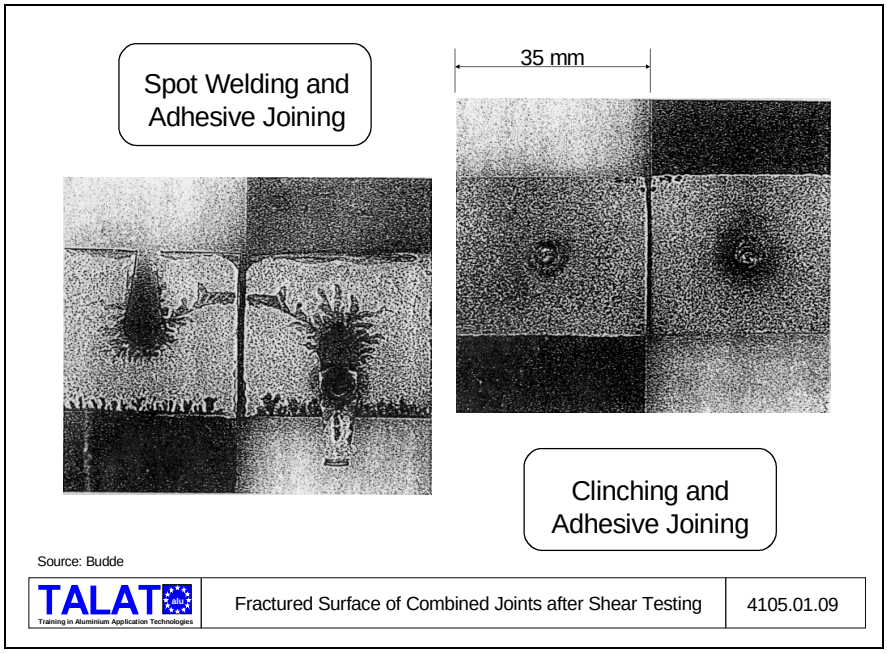
Clinching with or without local incisions is an interesting technology which could be used for combined joints and shall, therefore, be illustrated for combinations with adhesive joining. The following remarks generally apply also to other mechanical fastenings.



Fractured Surfaces of Combined Joints after Shear Testing

During the clinching process, aluminium shaped sheet components and profiles are joint together according to the quasi form locking principle simply through the action of local plastic material deformation without using auxiliary parts or thermally influencing the microstructure.

Material spray, which occurs as a joint defect due to the high material pressure in the spot welded region, thereby reducing the joint strength, is absent in joint combinations of clinching and adhesive joining (**Figure 4105.01.09**).

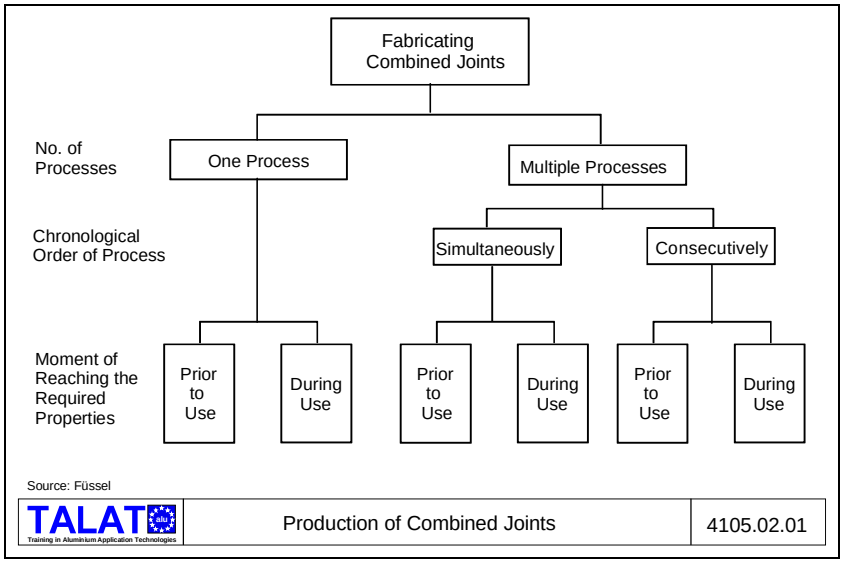


4105.02 Production Considerations

- Production of combined joints
- Production variants for combined joints
- Technical operations in the production of an adhesive-clinch joint combination
- Methods of producing adhesively joint and clinched fastenings
- Form of clinched joints with and without adhesives

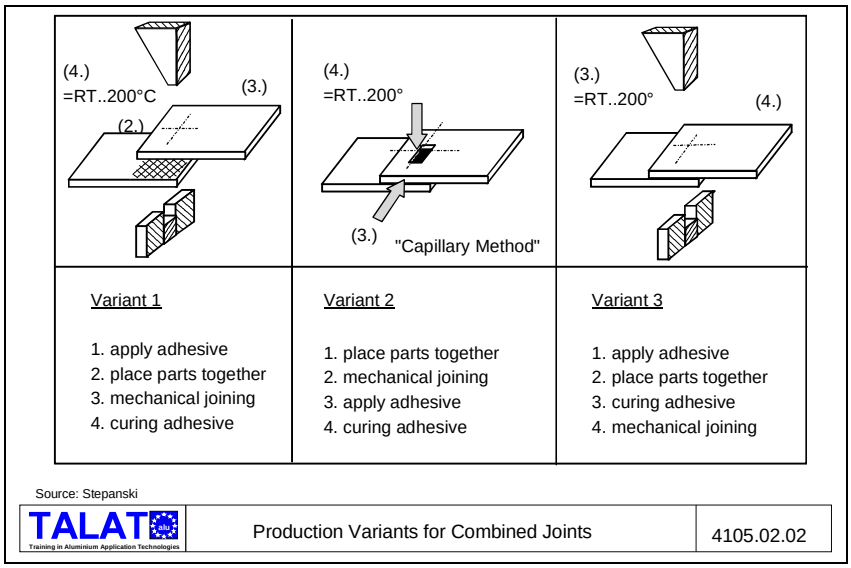
Production of Combined Joints

Joint combinations consisting of more than one elementary joint can be fabricated by producing the individual joints either simultaneously or one after the other (see **Figure 4105.02.01**). This chronological order can influence the properties of the joint.



Production Variants for Combined Joints

In principle, three variants are possible for the consecutive production of adhesive joining and mechanical joining (see **Figure 4105.02.02**).



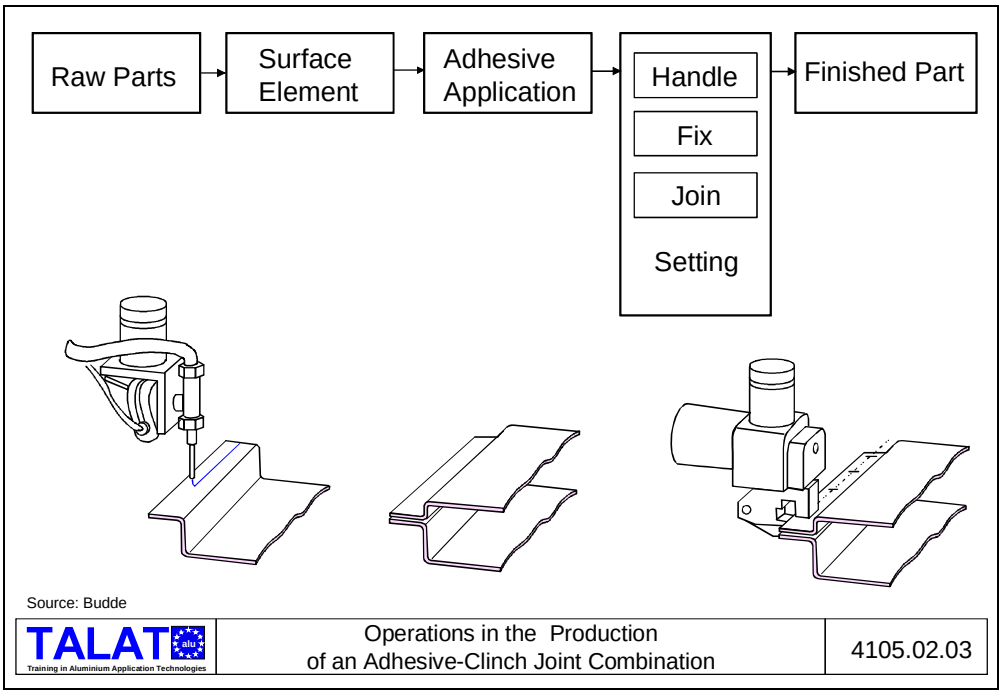
In the so-called "capillary" method, a mechanical joint is first prepared and then an adhesive of low viscosity is brought into the joint crevice. In this variation - which is characterised by a clear separation of the parts to be joint - the adhesive serves generally as a sealant and/or as an inhibitor for corrosion.

The adhesive joining of sheet and profile parts followed by a mechanical fastening process, the latter being used to improve the peeling strength of the joint, has till now played only a secondary role.
Another fastening process has been found to be industrially most suitable for making combined joints, especially for mass production. In this process, the adhesive is first

applied to the parts and then, before the adhesive hardens, followed by a mechanical joining process which goes through the unhardened adhesive. The hardening then follows as usual, depending on the type of adhesive used.

Technical Operations in the Production of an Adhesive-Clinch Joint Combination

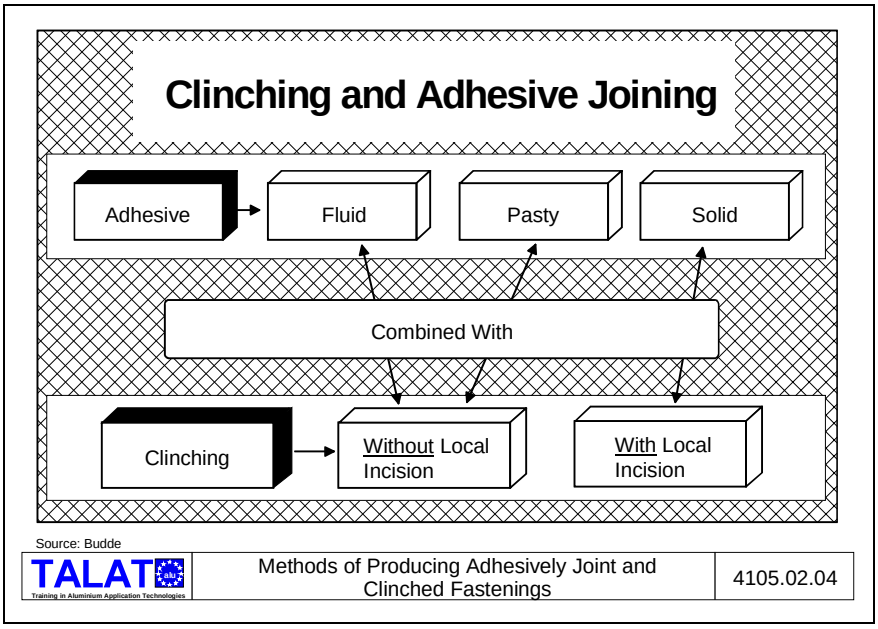
A closer look at the individual process steps involved in the production of the combined adhesive-clinch joint shows that the combined adhesive-mechanical joining process can be easily integrated in the mass production of thin sheet constructions (**Figure 4105.02.03**).



Methods of Producing Adhesively Joint and Clinched Fastenings

The advantage of using clinching instead of spot welding in combination with adhesive joining is that the former allows the use of not only fluid and pasty adhesives but also of adhesive foils and bands (**Figure 4105.02.04**).

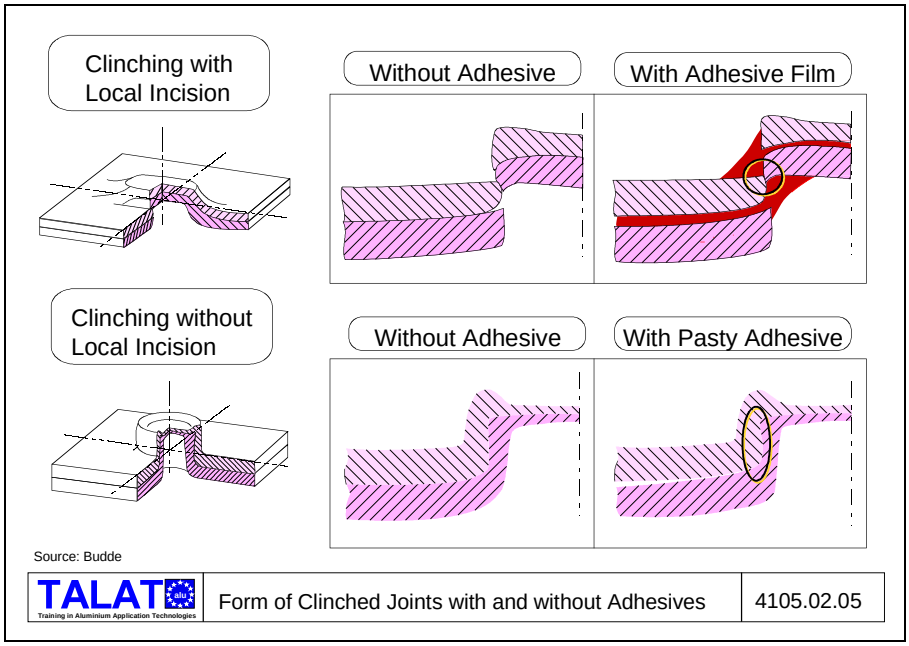
Solid adhesives have special advantages, both as far as process technology as well as health aspects are concerned.



Form of Clinched Joints With and Without Adhesives

Clinching without local incision can be used as the mechanical fastening partner for adhesive joining using pasty adhesives. On the other hand, clinching with local incision is used together with adhesive foils and bands.

The geometry of the joint element of combined clinched fastenings illustrates that in spite of the presence of adhesives, an optimal form of the clinch joint is created, assuming of course that an appropriate process technology is applied (**Figure 4105.02.05**).



4105.03 Properties of Combination Joints

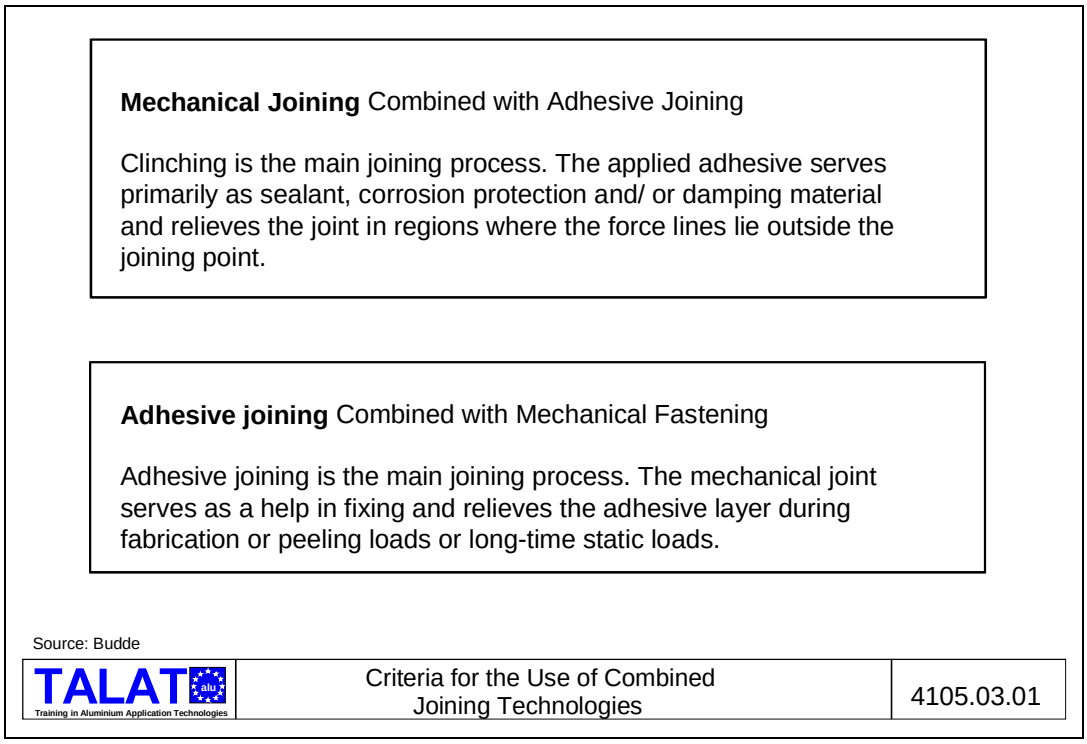
- Criteria for the use of combined joining technologies
- Results of fatigue tests with adhesive joints
- Impact strength of different joints
- Shear strength of different joints with and without ageing
- Comparison of properties of different joining technologies

Criteria for the Use of Combined Joining Technologies

In principle, the choice of the combined technology, mechanical fastening and adhesive joining, which may be used for joining in light constructions depends mainly on two application criteria.

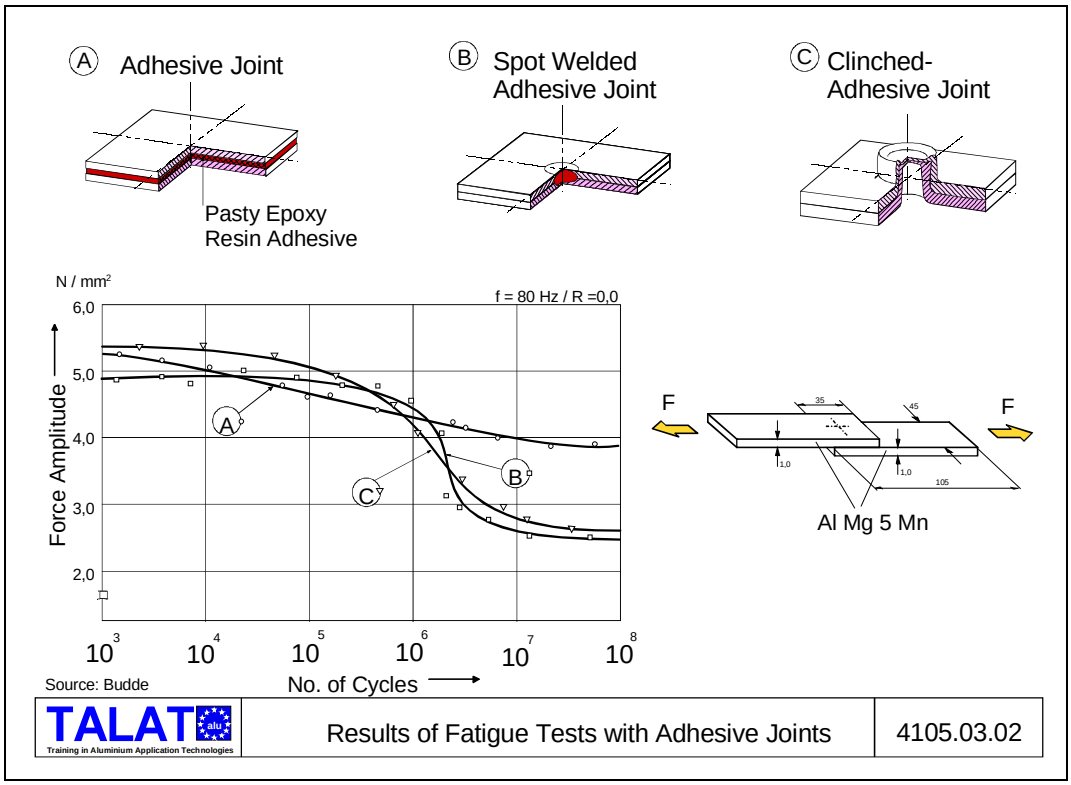
In mechanical fastenings combined with adhesive joining, the former is the main joining process. The adhesive used serves primarily as a sealant, corrosion inhibitor and/or as a damping material.

In adhesive joints combined with mechanical joining, the former is the main joining process. The mechanical joining serves as a positioning (fixing) help and helps the adhesive joint to withstand peeling forces and long-time static forces (**Figure 4105.03.01**).



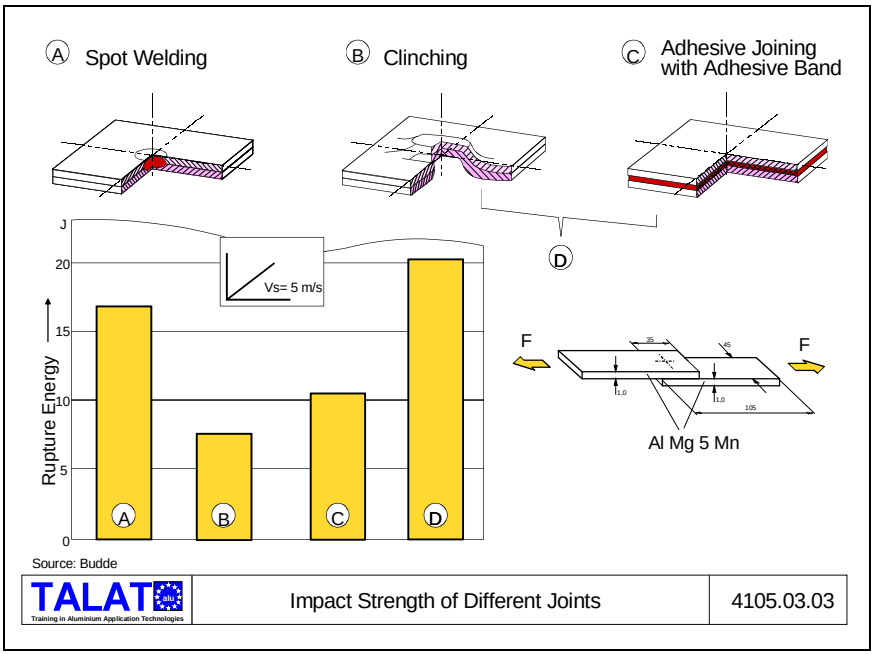
Results of Fatigue Tests with Adhesive Joints

The properties of the adhesive used are the main deciding criteria for the application. Under quasi static, dynamic and impact loading, the load carrying capacity of, for example, clinched adhesive joints compares well with that of spot welded joints (see **Figure 4105.03.02**). Under the action of dynamic loads, the geometric notch effect of the "point formed" joint element has a deleterious effect on the load carrying capacity of the combined joint.



Impact Strength of Different Joints

Joints made with ductile adhesives having a high deformability and low strength behave differently. Here again, depending on the loading, the joint strength is determined mainly by the clinch joint (**Figure 4105.03.03**). By giving proper consideration to factors like property profile and processing properties of the adhesive, it is basically possible to design combined joints with properties which are a combination of the individual properties of the joints.

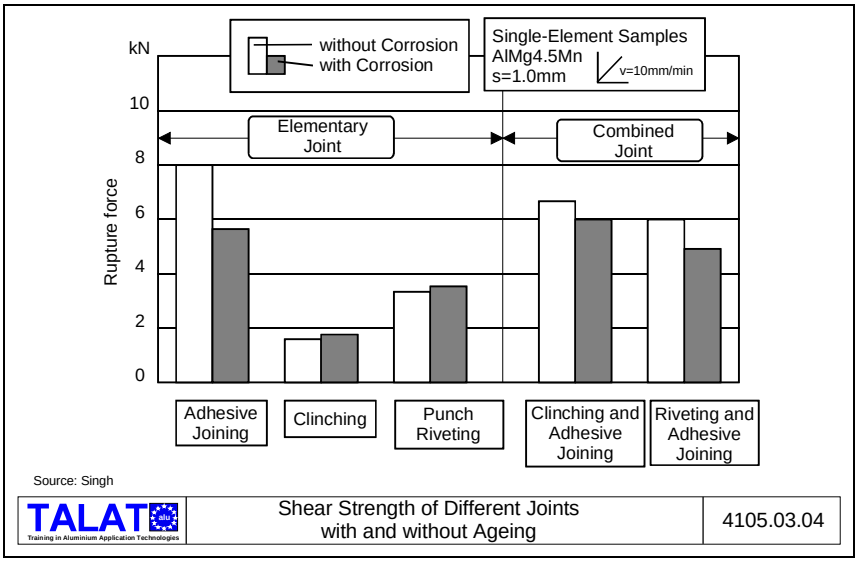


Shear Strength of Different Joints With and Without Ageing

In connection with combined fastenings of mechanical and adhesive joints, the aspect of ageing of the combined joint plays a central role.

It has been found that corrosion increases the strength of riveted and clinched joints of aluminium sheets (see **Figure 4105.03.04**). This is due to the fact that the corrosion products of aluminium occupy a larger volume than the uncorroded aluminium material. This increases the strain on the joint causing the force locking component to increase.

Although the mechanical fastening process can cause aluminium sheets to be pulled apart in the joint vicinity, the supporting action of the mechanical joint in the combined mechanical-adhesive joint greatly reduces the decrease in joint strength caused by ageing.



Comparison of Properties of Different Joining Technologies

Mechanical fastening methods, used alone or in combination with adhesive joining, improve the standard of quality as far as rigidity, damping of noise and vibrations, pressure tightness and corrosion protection are concerned, making this an interesting proposal for highly stressed aluminium constructions (**Figure 4105.03.05**).

Characteristics \ Joining Technology	Adhesive Joining	Spot Welding	Clinching	Riveting
Joint	Large Surface	Local	Local	Local
	Plane Surface	Uneven Surface	Deformed Surface	Damaged Surface
Properties	Very Sensitive to Environment	Conditionally Sensitive to Environment	Conditionally Sensitive to Environment	Sensitive to Environment
	Depend on Direction	Depend on Direction	Depend on Direction	Depend on Direction

Source: Budde

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4105.04 Literature/References

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4105.05 List of Figures