

TALAT Lecture 4107

General Summary and Future Trends

12 pages, 12 figures

Basic Level

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Objectives:

- to point out the need of data sources for designing mechanical joints
- to describe concepts for FEM-Modelling of mechanical joints

Prerequisites:

- General mechanical engineering background
- TALAT lectures 4101 - 4106

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4107 General Summary and Future Trends

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4107.01 Data Sources

- Problems in applying mechanical joining technologies
- Research aspects for mechanical fastening processes
- Incorporating experimental results in a technological data base „mechanical joining technology“
- Input mask for component design in a scientific based (expert) system


Problems in Applying Mechanical Joining Technologies

At present, the advantages of mechanical joining technologies are not used at all or at least not to the full, since users are not sufficiently acquainted with the special features and limits of the individual joining technologies.

Such a joining process can be used economically only if the user has a knowledge of the specific advantages and disadvantages, the possibilities and limitations of application, loading capacity, production tolerances etc. of the process.

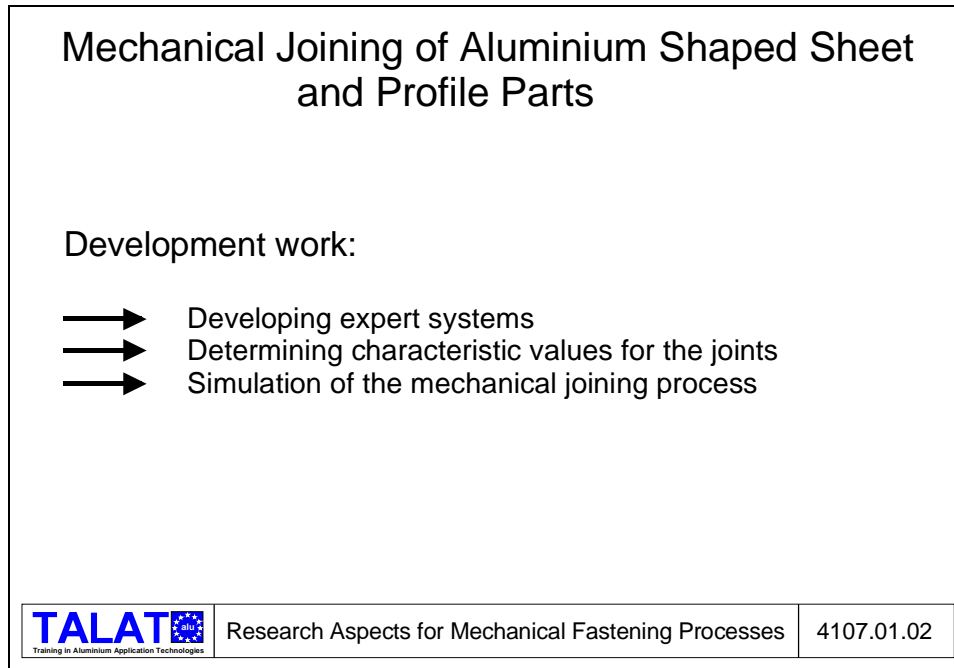
The application of mechanical joining technologies (i.e., clinching, etc.) has often proved to be an unsuccessful alternative to "conventional" joining methods (i.e., spot welding, etc.) because of the attempt to transfer technological parameters which have been optimised for "conventional" fastening methods directly to the mechanical joining process .

A result of this "1:1" type of thinking is that clinch joints deliver inferior results compared to spot welding, this being especially true for dynamically loaded aluminium constructions (see **Figure 4107.01.01**).

<h3>Mechanical Joining of Aluminium Shaped Sheet and Profile Parts</h3>		
Problems:		
→ High Force Required		
→ Influence of Joining Parts Surface		
→ Process Development not Complete		
→ Designing Basis not Available		
→ "1:1" Thinking		
	Problems in Applying Mechanical Joining Technologies	4107.01.01

Research Aspects for Mechanical Fastening Processes

A large amount of research is oriented towards intensifying the use of mechanical fastening methods for joining aluminium constructions (**Figure 4107.01.02**).

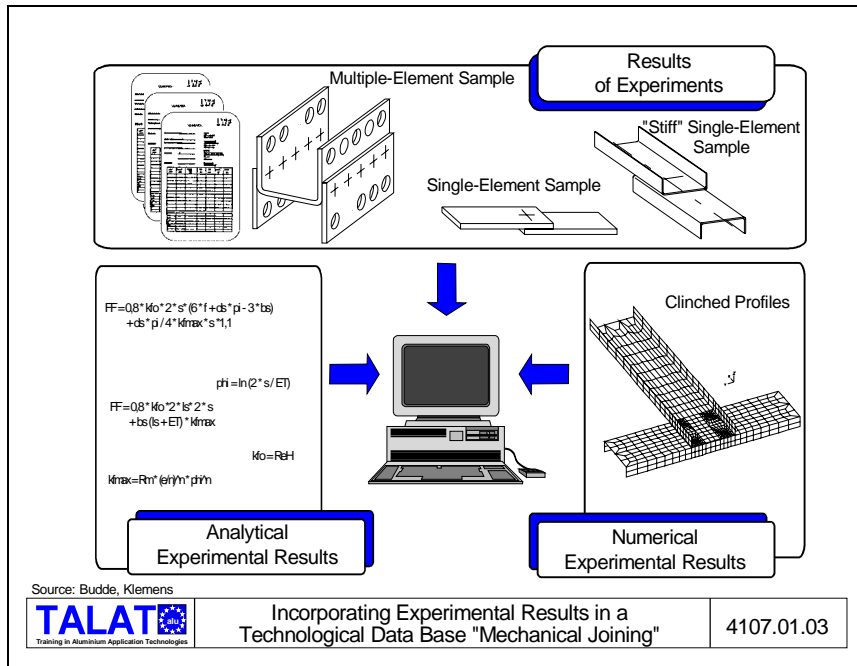


Besides developing scientifically based systems (expert system) and collecting and evaluating characteristic joining parameters, current research concentrates particularly on the methods of simulating of mechanical joining processes.

Incorporating Experimental Results in a Technological Data Base "Mechanical Joining Technology"

As a consequence of the numerous influencing parameters which have to be considered for choosing a mechanical fastening process, potential users do not generally possess the necessary production technology and economical background required for being able to use the process. The preparation of a scientifically based system (expert system) is necessary, in order to be able to offer users the specific knowledge required to improve the efficiency and quality of the appropriate mechanical joining technology.

For the data presentation, the knowledge of the constructive, production and economical aspects which is essential for using the mechanical joining technology has to be systemised and structured (**Figure 4107.01.03**).



Input Mask for Component Design in a Scientific Based (Expert) System

The expert system offers a double help to the user. Firstly, the user can learn about mechanical fastening technologies without having an actual problem in mind. Secondly, he can solve an actual joining problem with the help of this system.

In the first step, the user has to define his fastening problem using the expert system. Then the problem solving process is started in the form of a system-user dialogue. At the end of the session, the user is presented with the results of the consultation (**Figure 4107.01.04**).

This result can, for example, consist of a recommendation of a mechanical fastening method for joining an aluminium construction.

The screenshot shows the 'Technology storage' software interface. The main window displays a complex technical drawing of a component with various dimensions and annotations. The interface includes several input fields and buttons for configuring the design process.

Environmental influences:
 Min. temperature : -40 °C
 Max. temperature : 60 °C
 Operating temp. : 30 °C
 Rel. humidity : 70 %

Medium influence :

Stressing:
 tension / compression : static
 F = 4500
 shear stress : general - dynamic
 F₀ = 1350 N F_m = 900 N
 F_u = 450 N N = 1000000

Tool geometry:
 edged basic geometry: (all values in mm)
 PUNCH

component geometry

Material:
 Punch side: AIMg3 uncoated degreased
 Die Side: AIMg3 uncoated degreased

parts / year: 2340

Buttons: operate, result, return to : loading

Source: Budde, Klemens

TALAT Training in Aluminium Application Technologies

Input Mask for Component Design in a Scientific Based (Expert) System

4107.01.04

4107.02 FEM-Modelling

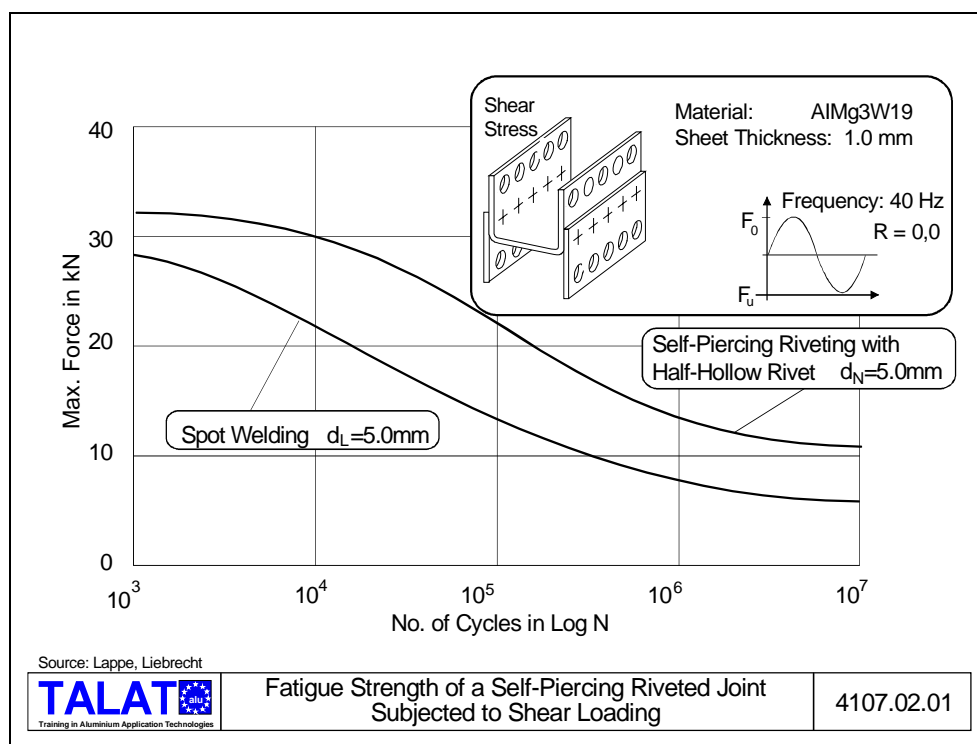
- Fatigue strength of a punch riveted joint subject to shear loading
- Schematic illustration of a mechanical fastening under 3-D loading
- Diagram for characterising a mechanical fastening element under quasi-static loading
- Model design for calculating a simulation for a clinch joint
- Single-step clinching process without local incision

Fatigue Strength of a Self-Piercing Riveted Joint Subject to Shear Loading

An aluminium construction can be dimensioned and designed only if data regarding the behaviour of the joint under the actual limiting conditions (material thickness, load type, influence of environment etc.) is available.

Sample forms, together with the appropriate experimental equipment, have been developed, making it possible to determine the necessary data for the existing combinations of material, thickness, mechanical joining technology, etc..

Experiments with multiple-point samples have shown that high strength joints are possible in aluminium sheets by using half hollow rivets for self-piercing riveting (Figure 4107.02.01).



Although the data gathered from the multiple-point samples can, in principle, be transferred to real structures, an adaption of this data is necessary for the real component to compensate for the different rigidities.

Schematic Illustration of a Mechanical Fastening under 3-D Loading

Besides multiple-point samples which are similar to the actual constructional components, single-element joint samples are also used to determine the characteristic mechanical values. Single-element samples are most useful for determining basic information about the characteristic values of mechanical joints being studied as well as for parametrical studies of mechanical joining, since a large number of disturbing influences are eliminated here.

In this connection, the aim is to obtain a single-element sample with which it is possible to obtain loading which is relevant practically. It must also be remembered here, that "locally formed" joints (like riveting, screw-fastening or clinching) are subject to a 3-D loading in actual use. This 3-D loading strains the joining element in two directions in the sheet plane (shear loading) and in a third direction normal to the joining plane (tensile loading) (see **Figure 4107.02.02**).

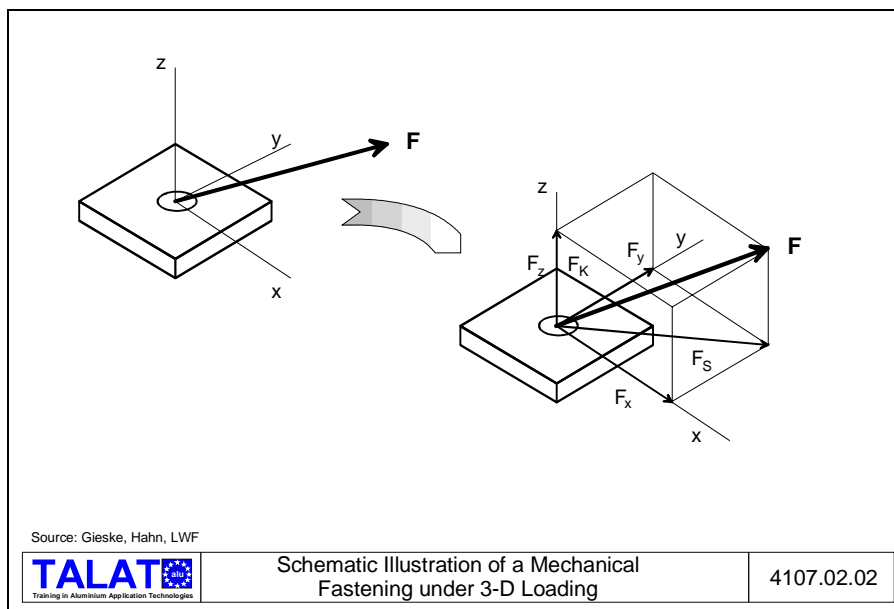
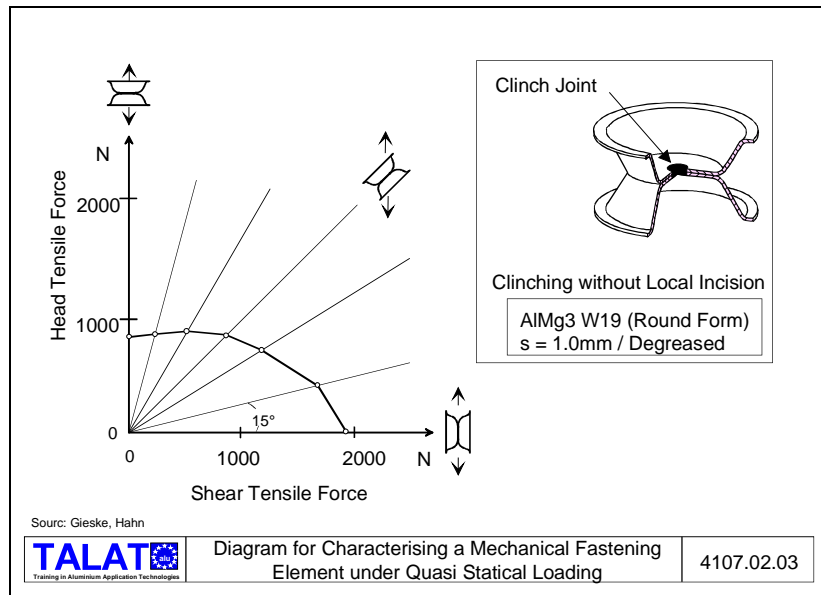


Diagram for Characterising a Mechanical Fastening Element under Quasi-Static Loading

New single-element samples have been developed, enabling the mechanical joint to be tested under combined loading. With these samples it is possible to determine and evaluate correlations among different loading directions and different loading types (**Figure 4107.02.03**).

Preliminary results obtained with an axially symmetrical clinch joint element without local incision, stress the enormous practical possibilities for evaluating mechanical joints.

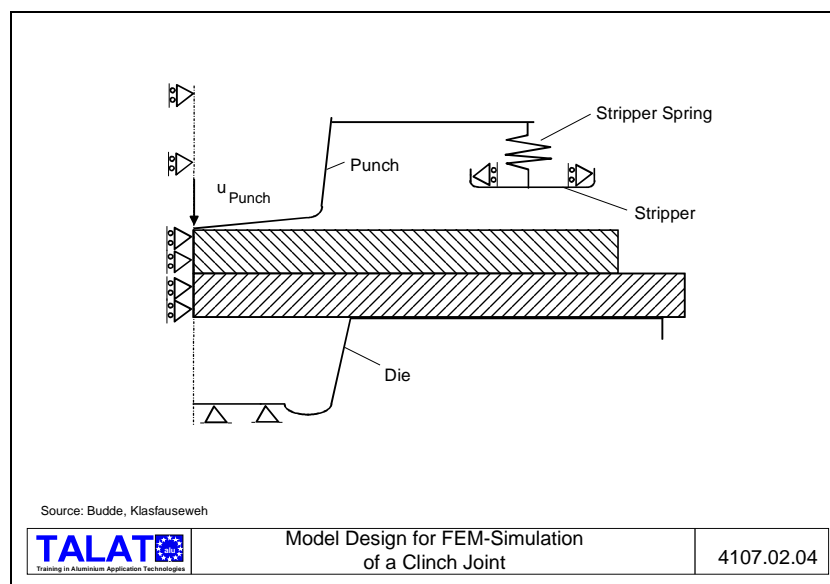


Model Design for FEM-Simulation for a Clinch Joint

In two-step and multiple-step clinching, a large range of joint thicknesses and material combinations can be joined by changing the operating parameters of the same tooling combination. On the other hand, different punch and die combinations would be necessary for single-step clinching. Currently, experiments are being conducted to help adapt the process for each individual joining problem.

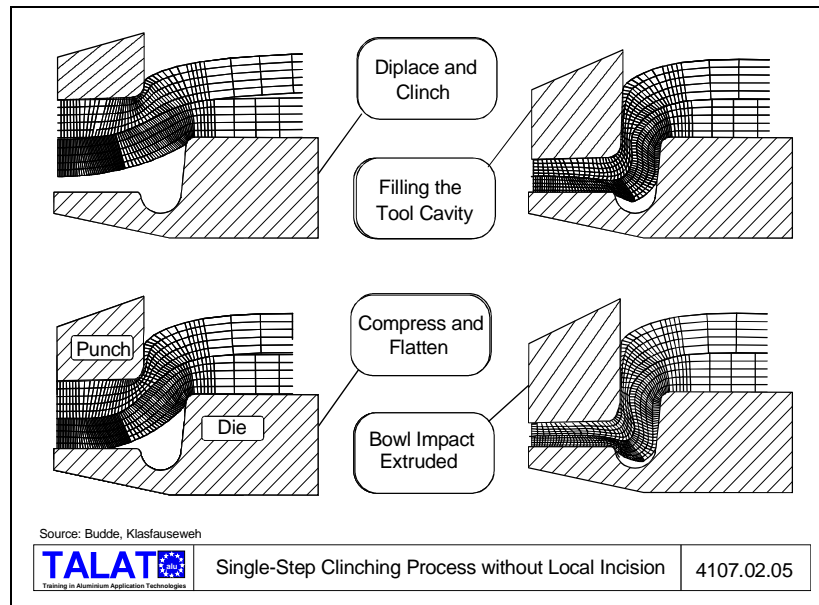
It is, however, possible to simulate mechanical joining processes with the help of non-linear finite element programmes.

The numerical study handles an axially symmetrical clinch element without local incision, manufactured using a rigid die (**Figure 4107.02.04**).



Single-Step Clinching Process without Local Incision

The results of the clinching simulation make it possible to optimise the fastening tools for different aluminium alloys and thicknesses. It will be possible to document or analyse the current state of the joining process (**Figure 4107.02.05**).



At present, it is not possible to predict the joint strength under different loading directions using further simulations. A comparison and evaluation of the results obtained using different forms of joint elements, is, however, a useful method for optimising the quality of mechanical fastenings, thereby enabling the use of these joining technologies in other applications, especially for load-carrying aluminium structures.

4107.03 Summary

- State of the art of mechanical technologies for joining aluminium
- Joining techniques as part of the design concept (designing assumptions)
- Joining technology as part of the design concept (application example)

State of the Art of Mechanical Technologies for Joining Aluminium

In summary, it can be concluded that the use of mechanical fastening technologies for joining shaped sheet and profile components can bring enormous competitive advantages (**Figure 4107.03.01**).


The state of the art of mechanical fastening technologies clearly shows that it is becoming increasingly possible to solve joining problems efficiently by using mechanical fastening technologies, especially clinching and punch riveting.

State of the Art of Mechanical Technologies for Joining Aluminium		
<ul style="list-style-type: none"> • Mechanical fastening is a "predictable and calculable" joining technology for the industrial user ! • Using mechanical fastening, it is possible to fabricate joints which are safe and reproductable ! • Mechanical fastening can be integrated in a continuous production process for the mass production of thin sheet constructions ! • Mechanical fastening offers not only technological but also economical advantages ! • The combination of mechanical fastening with adhesive joining opens the way for new applications ! 		
	State of the Art of Mechanical Technologies for Joining Aluminium	4107.03.01

Joining Techniques as Part of the Design Concept (Designing Assumptions)

The statement that modern applications can be designed more effectively using mechanical joining methods is valid only if the mechanical fastening technology is not judged solely on the basis of its "practicability".

The mechanical joining technology also has an influence on the performance of the aluminium construction as a whole, a fact which should be considered when designing the construction (**Figure 4107.03.02**).

Specific Application of Mechanical Fastening in Modern Structural Design Concepts		
Assumptions :		
→	The mechanical fastening technology should not be considered only on the basis of its "feasibility" !	
→	Mechanical fastening technologies are always an integral part of the construction	
and		
influence the performance details, so that this should be considered in the planning phase of the design !		
	Joining Techniques as Part of the Design Concept (Designing Assumptions)	4107.03.02

Joining Technology as Part of the Design Concept (Application Example)

The use of mechanical fastening technologies opens the way for new design concepts for aluminium shaped sheet and/or profile parts, the space-frame concept being such an example (**Figure 4107.03.03**).

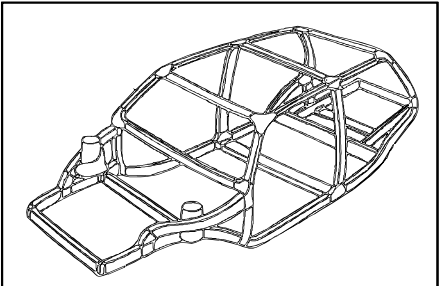
In contrast to the "conventional" joining technologies, new possibilities for rationalising using changed manufacturing processes and new aluminium materials are possible here.

Application Examples for Mechanical Joining Technologies


- ➔ New Designing Possibilities for Aluminium Formed Sheet and Profile Parts
- ➔ New Aluminium Materials Can be Utilised
- ➔ Better Functional Characteristics Can be Obtained
- ➔ Fabrication Process Steps Are Not the Same as Those Used for "Conventional" Joining Processes
- ➔ New Possibilities for Rationalising

e.g.
for

Space - Frame - Concept



Source: Patrick, Sharp

	Joining Technology as Part of the Design Concept (Application Example)	4107.03.03
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4107.04 Literature/References

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4107.02.02	Schematic Illustration of a Mechanical Fastening Under 3-D Loading
4107.02.03	Diagram for Characterising a Mechanical Fastening Element under Quasi-Static Loading
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