INSTITUTO DE PESQUISAS TECNOLÓGICAS

COMUNICAÇÃO TÉCNICA

Nº 179294

Study of properties of aluminun alloys joints for use in motor vihicles

Leonardo Rodrigues Danninger
Ana Paola Villalva Braga
Marcelo Gonçalvs

Palestra apresentado no CONGRESSO ANUAL DA ABM, 77., 2024, São Paulo.
14 slides

Instituto de Pesquisas Tecnológicas do Estado de São Paulo
S/A - IPT
Av. Prof. Almeida Prado, 532 | Cidade Universitária ou
Caixa Postal 0141 | CEP 01064-970
São Paulo | SP | Brasil | CEP 05508-901
Tel 11 3767 4374/4000 | Fax 11 3767-4099

www.ipt.br

STUDY OF PROPERTIES OF ALUMINUM ALLOYS JOINTS FOR USE IN MOTOR VEHICLES

Leonardo Rodrigues Danninger – Instituto de Pesquisas Tecnológicas do Estado de São Paulo (IPT) / Escola Politécnica da USP (EPUSP-PMT)

Ana Paola Villalva Braga – Instituto de Pesquisas Tecnológicas do Estado de São Paulo (IPT)

Marcelo Gonçalves – Alpina Consultoria Tecnológica e Educacional

September 5th, 2024

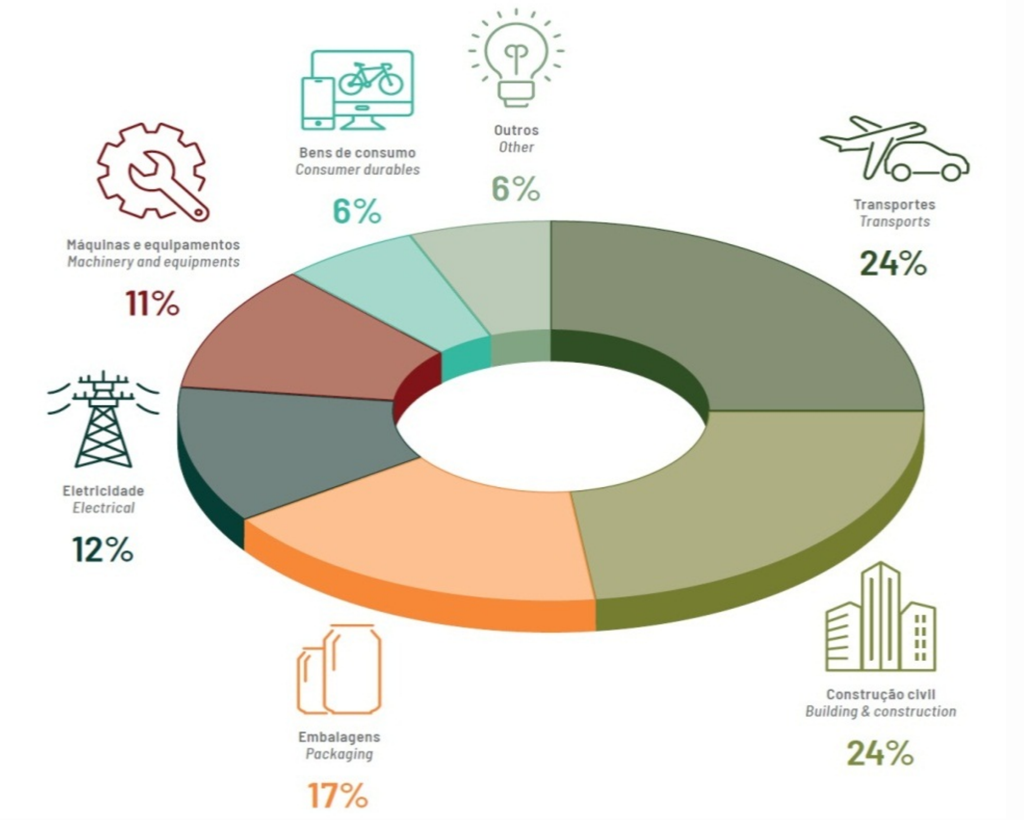
Introduction

Aluminum alloys

- ✓ Excellent combination of properties
  - ✓ Low Density
  - ✓ Availability of high-strength alloys for structural applications
  - ✓ Corrosion resistance
  - ✓ Excellent recyclability

Main uses of Aluminum alloys

- ✓ Transportation
- ✓ Building and Construction



Global Aluminum Consumption by Sector

Introduction

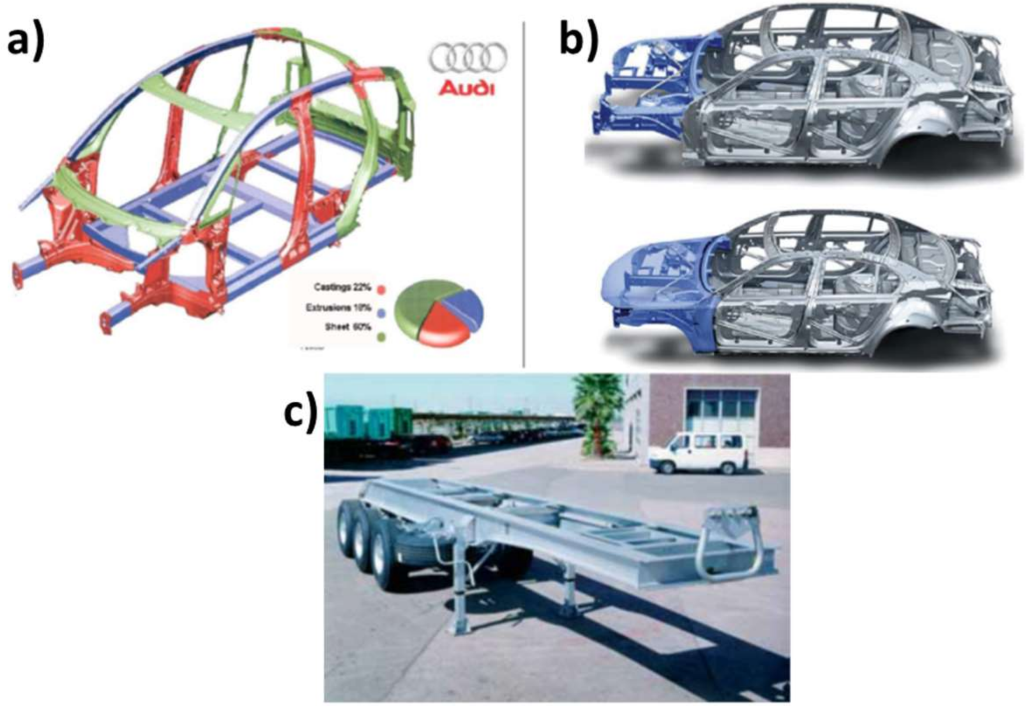
<u>Advantages of Aluminum in Automotive and Transportation Industry</u>

✓ Weight reduction → 40 to 50%

  - ✓ Energy Efficiency
  - ✓ Reduction in polluting emissions
  - ✓ Reduced operating costs for road transportation

<u>Important drawback</u>

✓ Joining of structural components



Examples of Aluminum Vehicle Structures: a) Original Aluminum ASF (Audi Space Frame), Audi A2; b) Hybrid Al-Steel Structure, BMW 5 Series (front section in aluminum, shown in blue); and c) Aluminum Dump Truck Chassis.

Experimental procedure
Preparation of joints

Material

✓ AA6XXX → thicknesses from 2 to 5 mm

Identification	Process	Alloy and thicknesses (mm)
Adhesive Joint	Adhesive	6082-T6 (5) + 6082-T6 (5)
Riveted Joint	Mechanical Fastening	6082-T6 (5) + 6082-T6 (5)
Hybrid Joint	Adhesive + Mechanical Fastening	6082-T6 (5) + 6082-T6 (5)
MIG Joint	MIG	6005A-T6 (2) + 6005A-T6 (2)
FSW Joint	FSW	6005A-T6 (2) + 6005A-T6 (2)

Analyzed joint

Experimental procedure
Preparation of joints – Lap Joint

Adhesive Joint

✓ LORD®852/25GB + LORD®Accelerator 25GB

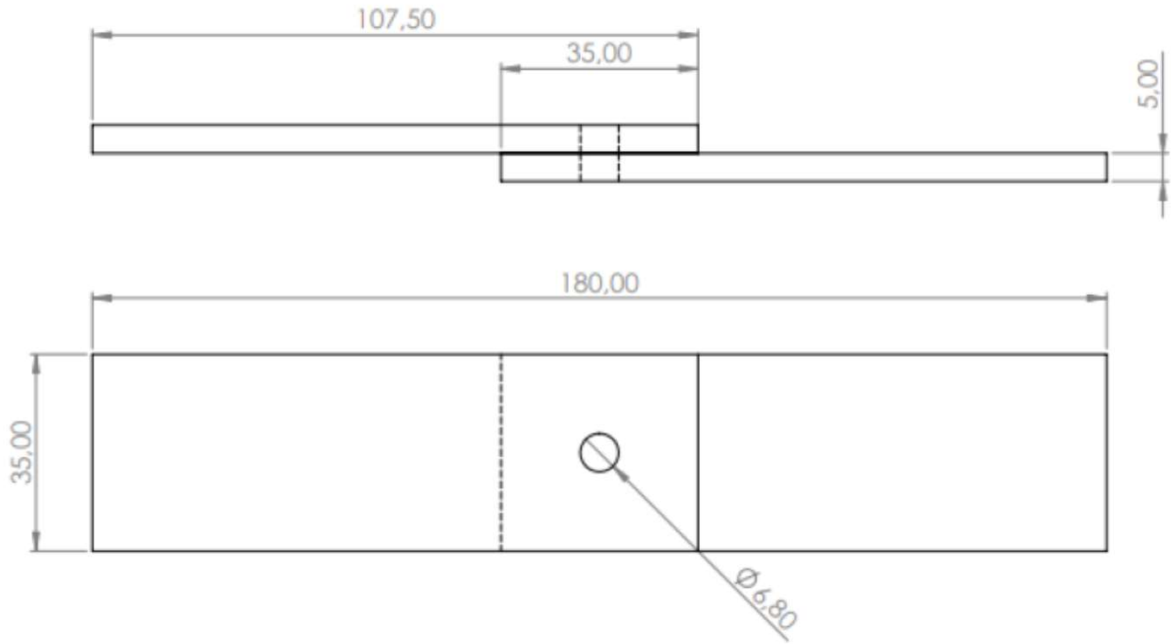
Riveted Joint

✓ Rivquick®Varilock mechanical fastener

Hybrid Joint

✓ Adhesive bonding followed by rivet application

Overlap Area → 35 mm² x 35 mm²



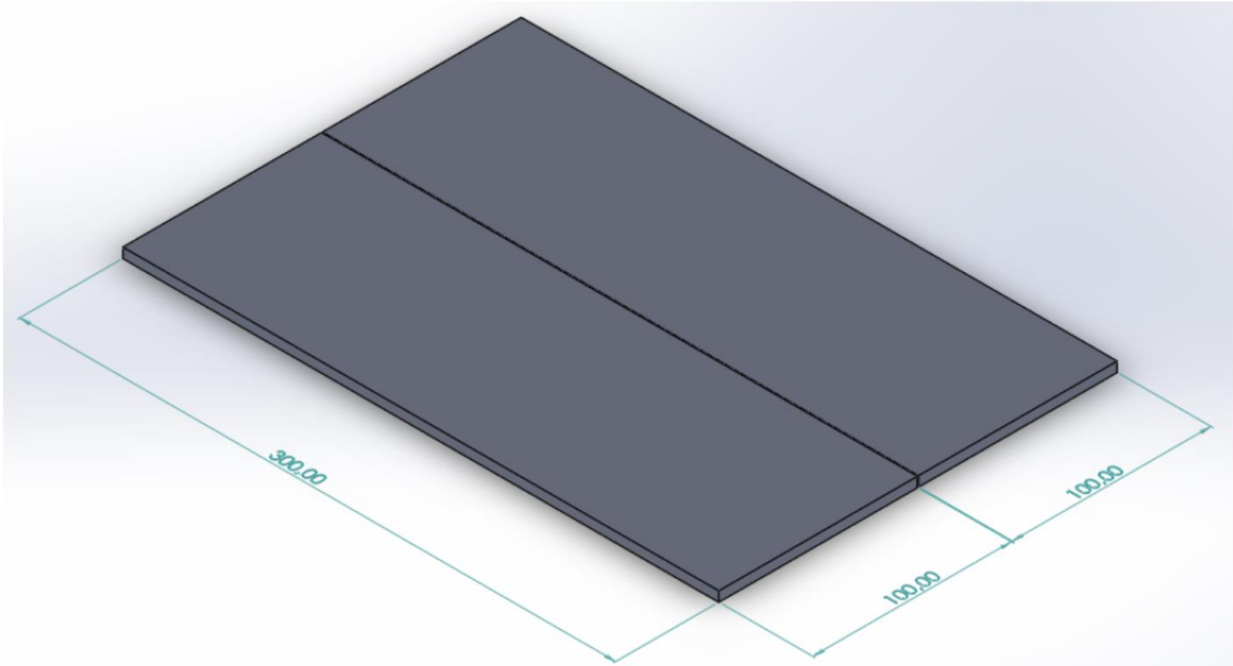
Geometry of the Lap Joint Coupons. The adhesive-only joints did not have the central hole.

Experimental procedure
Preparation of joints – Butt Joint

Process

- ✓ MIG Welding
- ✓ FSW Welding

Specimens extracted from central regions of the coupons for evaluation of mechanical properties



Geometry of the Butt Joint Coupons

Results and Discussion
Lap Joint – Tensile Test

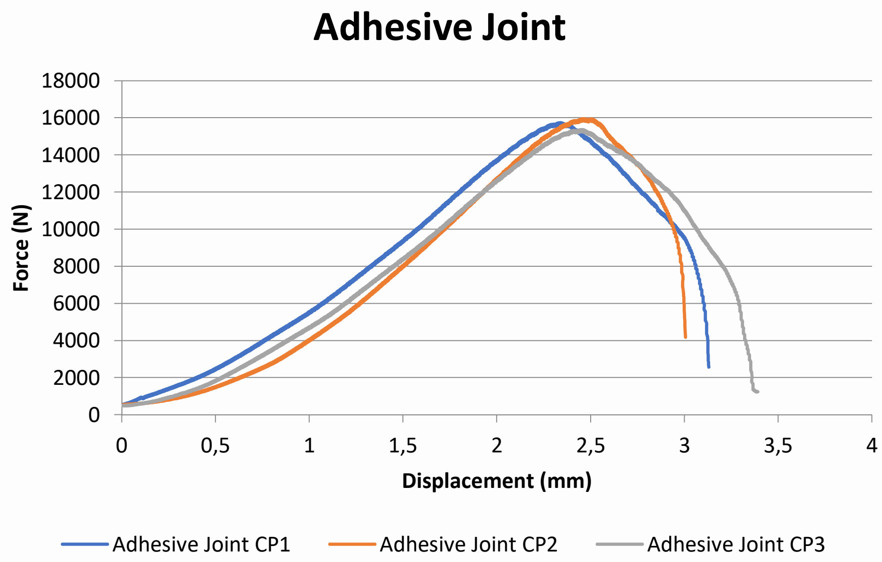
<u>Adhesive Joint</u>

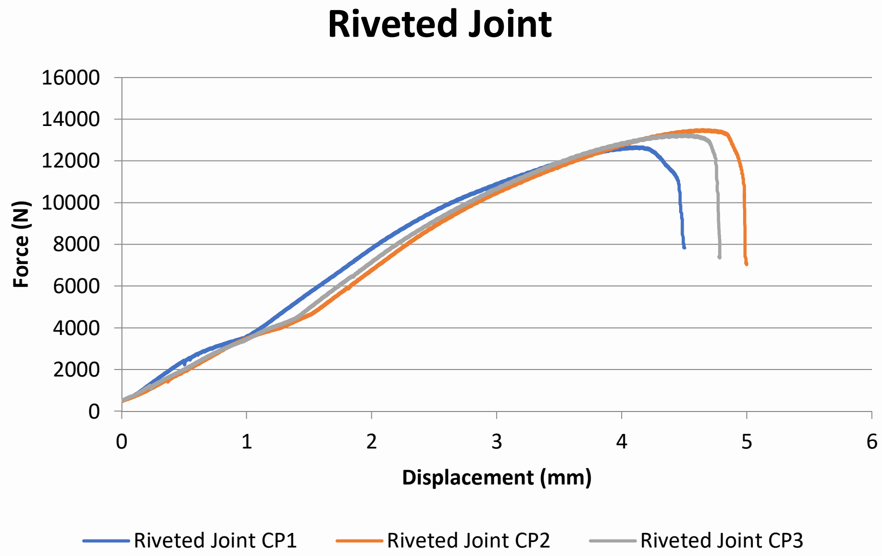
- ✓ Cohesive fracture → no adhesion problems
- ✓ LBC = 15961 N

<u>Riveted Joint</u>

- ✓ Rivet Body Failure
- ✓ LBC = 13146 N

* LBC = load-bearing capacity





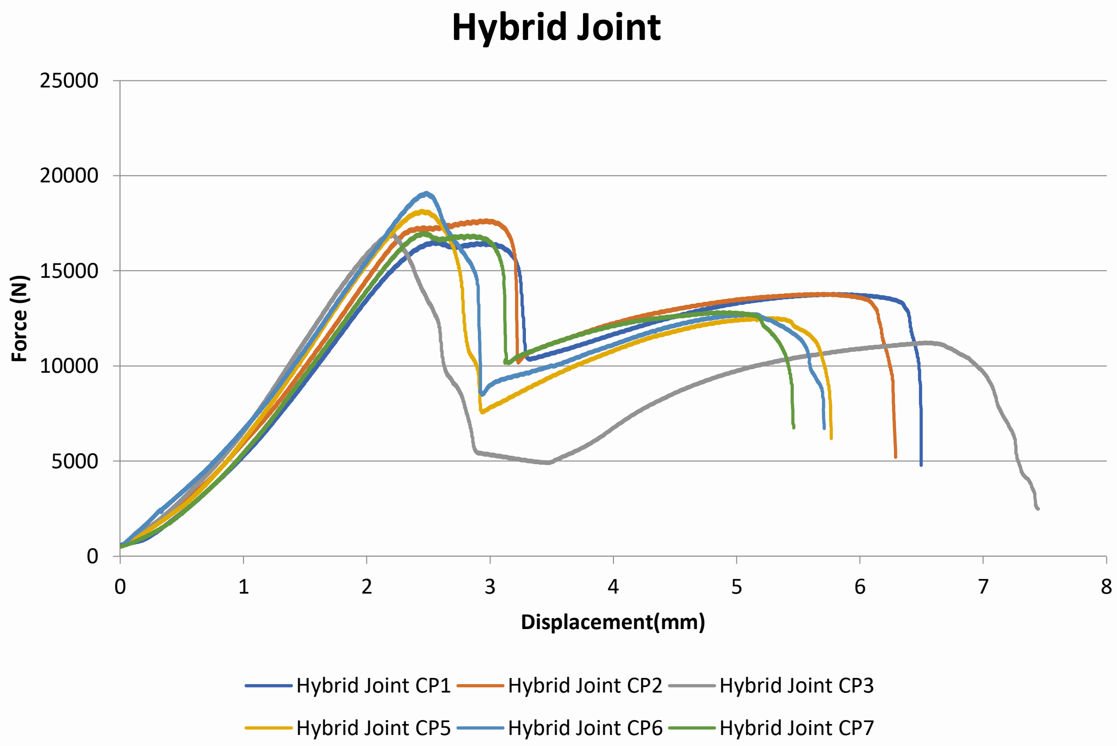
Results and Discussion
Lap Joint – Tensile Test

Hybrid Joint

- ✓ Best performance due synergistic effect
  - ✓ Rivet: Axial loads
  - ✓ Adhesive: Stress Distribution

Two Stages Fracture

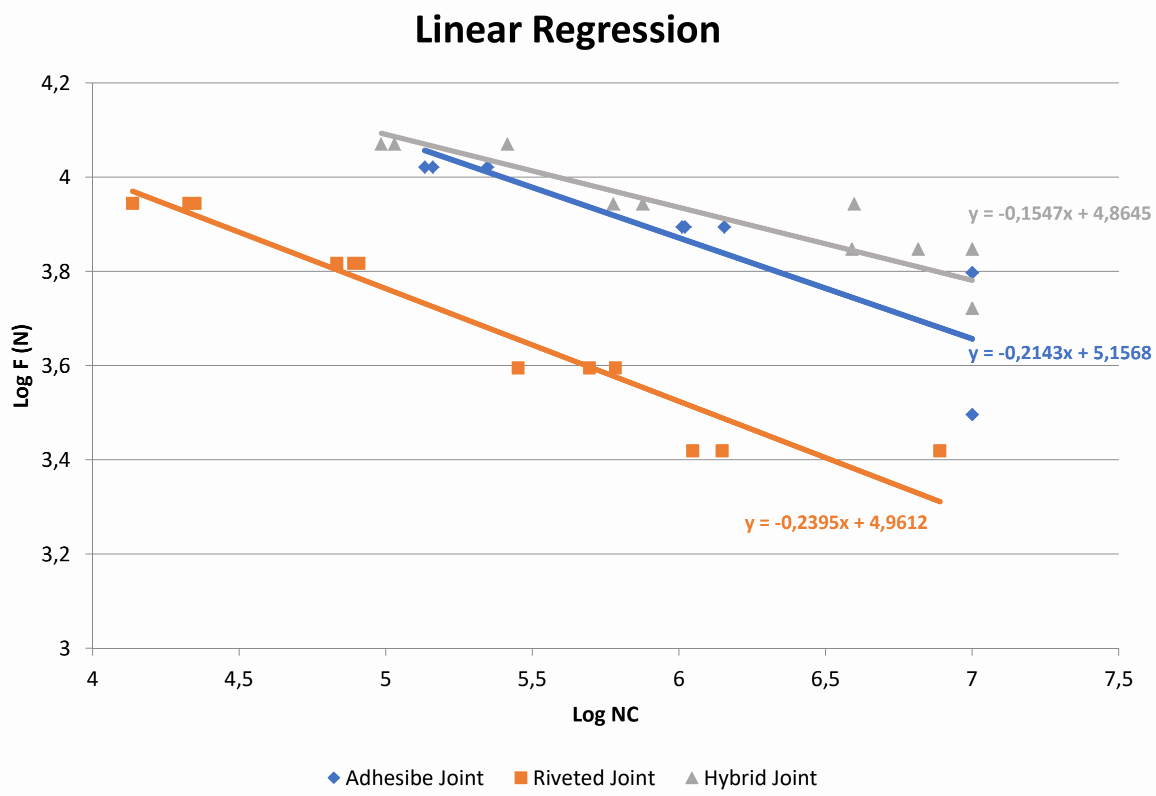
- ✓ Adhesive Cohesive Failure + Rivet Body Failure
  - ✓ Intrinsic to the Hybrid Joint



Identification	Mean Load Bearing Capacity - LBC (N)
Adhesive Joint	15691
Riveted Joint	13146
Hybrid Joint	17584

Results and Discussion
Lap Joint – Fatigue Test

Identification	Fatigue Limit (N) 1,00E+07	Fraction of the Mean LBC
Adhesive Joint	4536	29%
Riveted Joint	1926	15%
Hybrid Joint	6048	34%

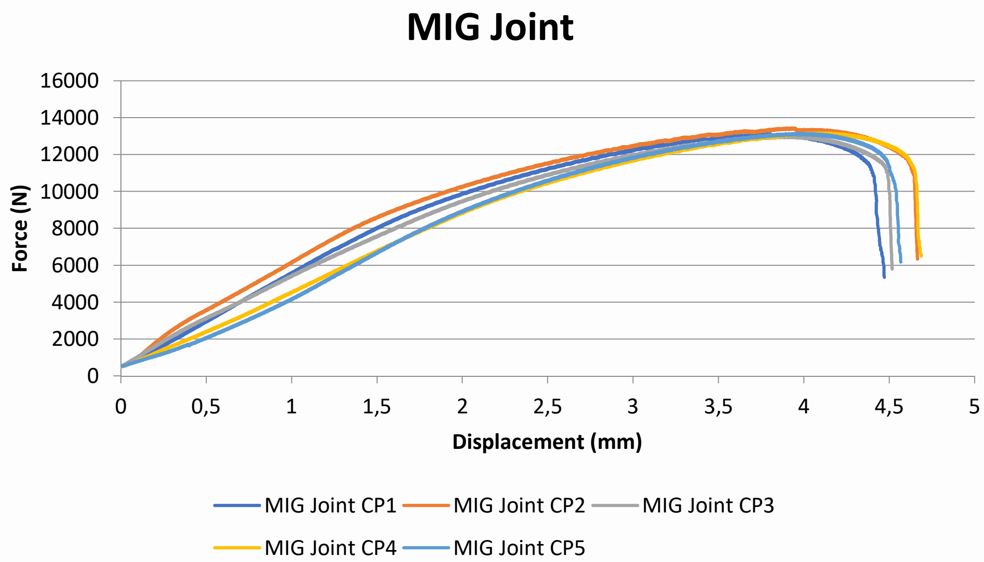


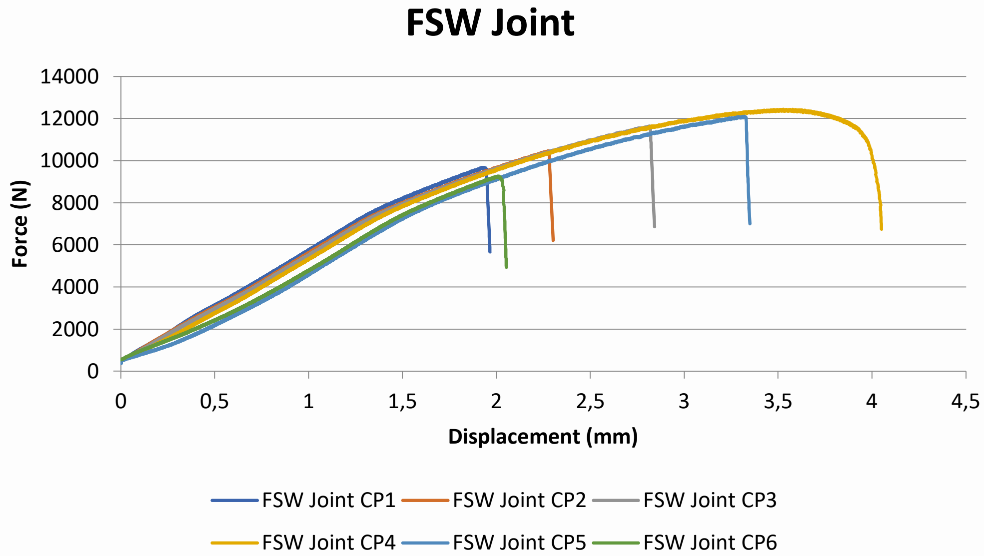
Results and Discussion

Butt Joint – Tensile Test

<u>MIG Joint vs FSW Joint</u>

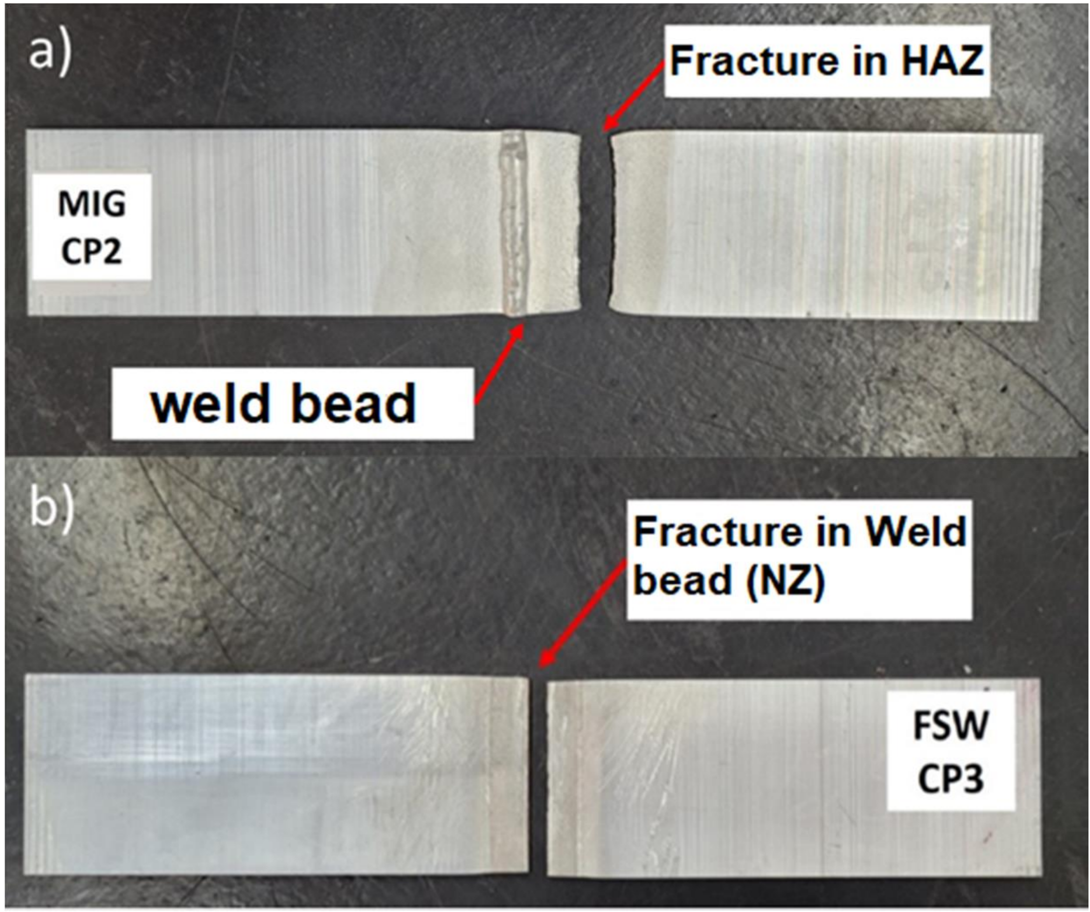
- ✓ MIG joint → Reasonably better tensile tests performance and lower scatter of results
- ✓ FSW joint → greater scatter in force and maximum displacement





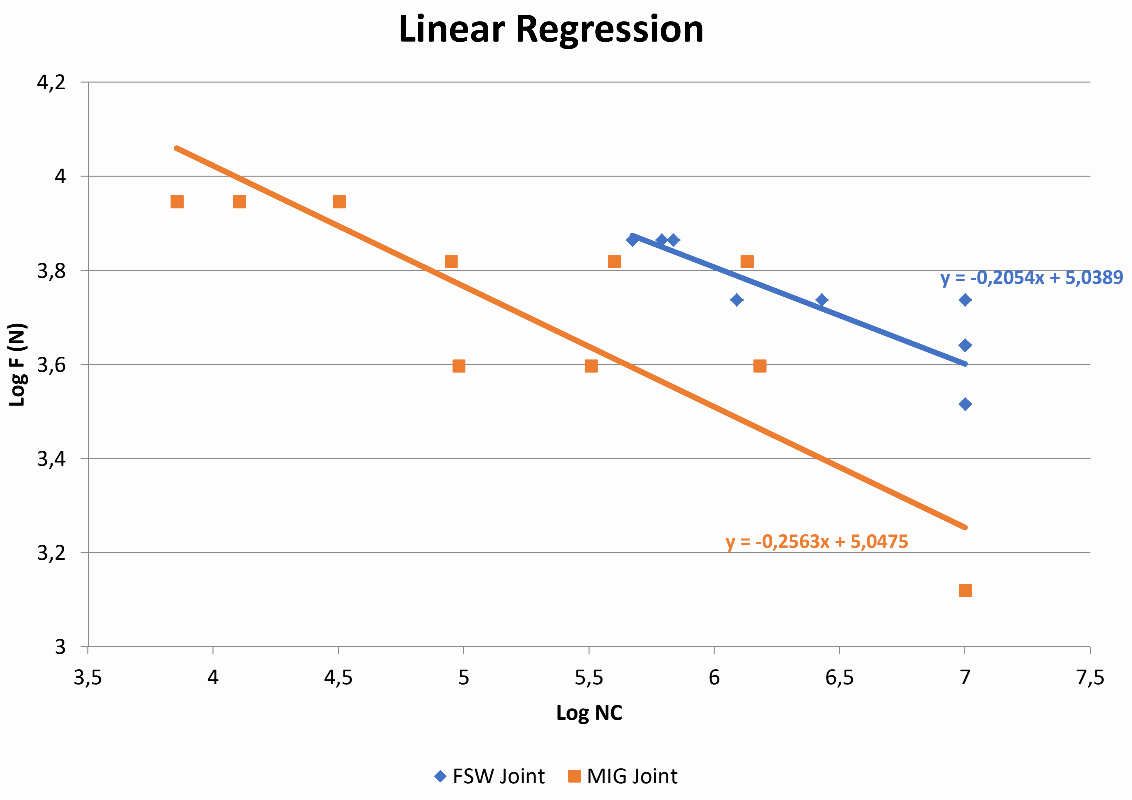
Results and Discussion
Butt Joint – Tensile Test

Identification	Mean LBC (N)	Failure location
MIG Joint	13187	HAZ
FSW Joint	10936	NZ



Results and Discussion
Butt Joint – Fatigue Test

Identification	Fatigue Limit (N) 1,00E+07	Fraction of the mean LBC
MIG Joint	1792	14%
FSW Joint	3991	36%



<u>In fatigue testing, the FSW Joint performed better than the MIG Joint</u>

- ✓ Surface roughness of the MIG weld bead
- ✓ High thermal inputs → Formation of coarser intermetallic second- phase particles

Conclusions

Based on the studies carried out and the results obtained, the effects of the type of joining technique on the basic mechanical strength of aluminum alloy joints used in motor vehicles structures could be better understood. Synthetically, the following could be concluded:

- ✓ For the **lap joints** here studied the results pointed out that the hybrid joints performed reasonably better than the adhesive or the riveted joints. Such enhanced behaviour was observed for both static (tensile) and dynamic (fatigue) testing. These findings revealed a synergistic combination of the favorable effects of adhesive and rivet (mechanical fastening) on the mechanical performance of the hybrid joints.
- ✓ As for the **butt joints** the tensile test results indicate that both MIG and FSW welding techniques developed somewhat similar load-bearing capacities. However, results from dynamic tests suggest that the MIG process might have been detrimental to the fatigue resistance of the joints probably due to undesirable effects such as high surface roughness in the weld bead, the presence of microporosity and coarse microstructural features inherent to the high thermal input and solidification phenomena associated to the MIG process.

ACKNOWLEDGEMENTS

The financial and technical support of the following companies and institutions are gratefully acknowledged: EMBRAPII, ABAL, AETHRA, BÖLLHOFF, CBA, ESAB, FSW BRASIL, HYDRO EXTRUSIONS, MAXION STRUCTURES, METALSA, NOVELIS, PARKER LORD, PROLIND, RANDON, STELLANTIS, RECICLA BR and TRANSVALOR BRASIL.

THANK YOU

Leonardo Rodrigues Danninger

leonardo.danninger@usp.br

ldanger@ipt.br

LinkedIn