Dr. Hartwig Lohse

Bonding of Composite Materials in Automotive Engineering –

Opportunity for a Reduction of CO_2-Emissions

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

Inhalt

- Introduction
- Adhesive Bonding – a next generation technology
- Adhesives for bonding composite materials
- Joint design for adhesive bonding
- Processing and cross-linking of adhesive in series production
- New applications, progress and trends - Outlook

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

Composites in Automotive Engineering

1946: Stout `46	Case study by Owens Corning – full composite car body
1972: Renault 5	First SMC bumper
1980: Audi Ur-Quattro	boded SMC trunklid
1984: Renault Espace	Composite side panels bonded to the hot dipped steel body structure
1982: Citroen BX	First high volume passenger car with SMC/BMC exterior body parts (SMC-front hood, BMC liftgate)
1989: Volvo Truck	bonded SMC air deflector
2002: PSA/FIAT	individualization through SMC liftgates

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

Composite Materials in Automotive Engineering

- Design freedom
- Individualization
- Cost benefits at low to medium volumes – speed to market
- Fully permeable to radio signals – antennas can be invisibly mounted within the component
- Sound dampening properties
- Corrosion resistance
- Weight reduction

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

Government regulators demand ever high fuel economy performance and lower CO_2-emissions. – EU 443/2009 defines the OEM-average CO2-emission of newly registered cars have to be below 95 g/km.

Car manufacturer's response:

- **Optimization of the power train (engine, gear box). Cylinder capacity reduction by maintaining performance**
- **Hybrid engine – Electro car**
- **Reduction of air and rolling drag**
- **Weight reduction (100 kg → 8,5 g CO_2/km = 0,3 l/100 km)**
- **...**

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

An Assessment of Mass Reduction

Opportunities for a 2017 – 2020 Model Year Vehicle Program

Prepared by: Lotus Engineering Inc.

Submitted to: The International Council on Clean Transportation (ICCT)

March 2010

Based on Toyota's Verza 2009 model weight reduction measures by using alternative materials and joining technologies are discussed

Weitere Informationen ICCT: www.theicct.org

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

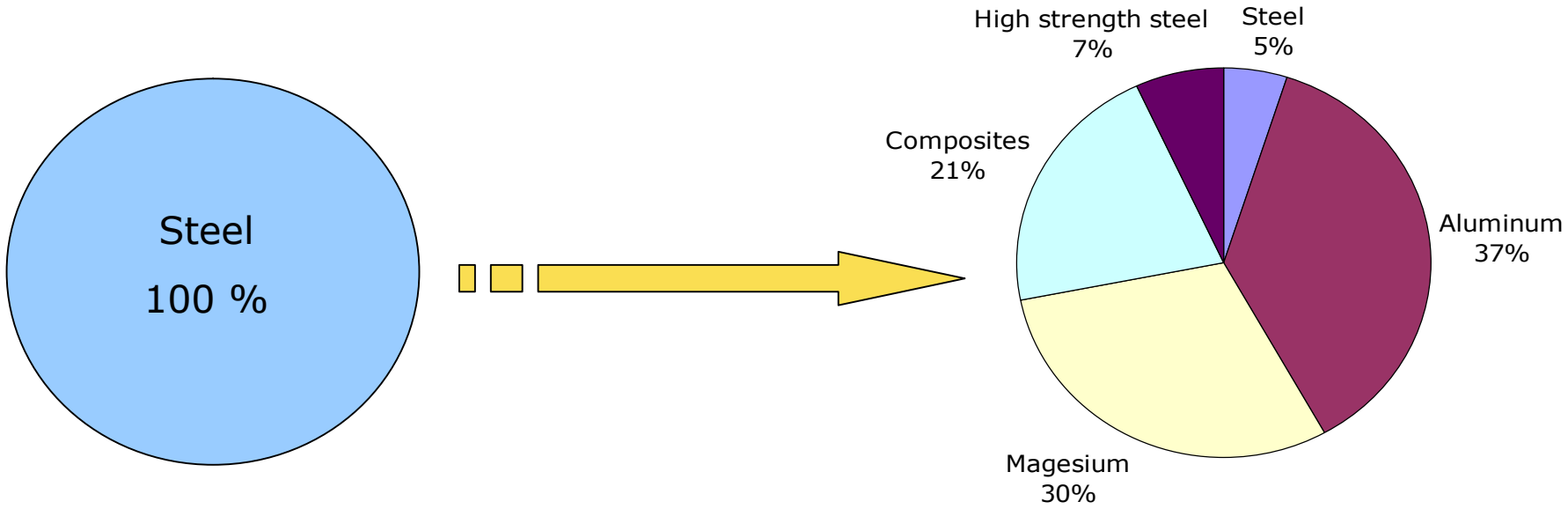
Body Structure

An Assessment of Mass Reduction Opportunities for a 2017 – 2020 Model Year Vehicle Program

Prepared by: Lotus Engineering Inc.

Submitted to: The International Council on Clean Transportation

March 2010



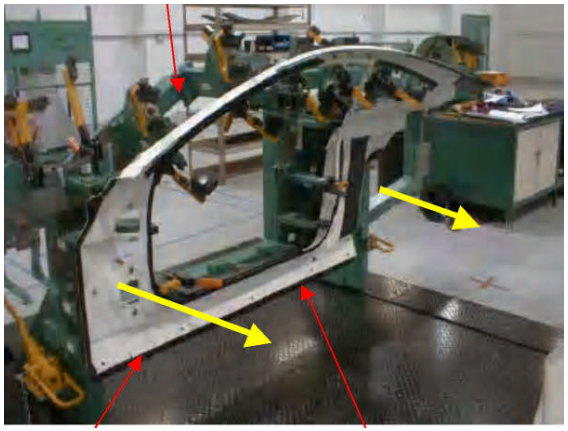
> 400 individual parts/ 382 kg

211 individual parts/221 kg

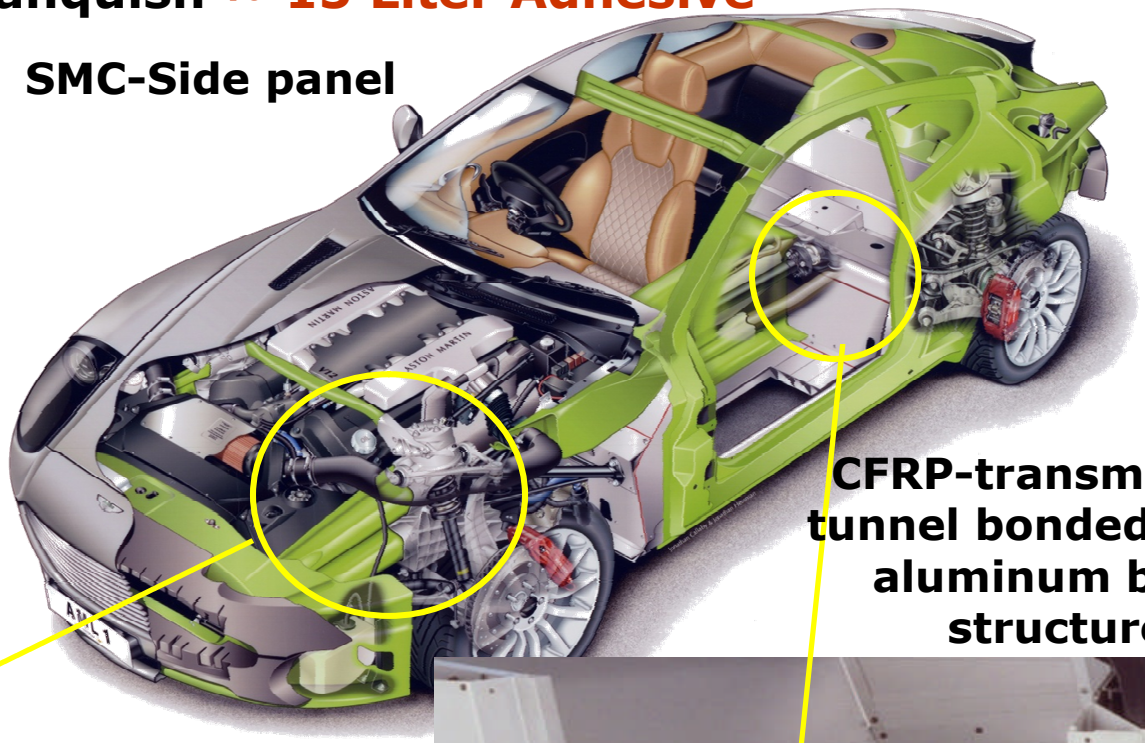
© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

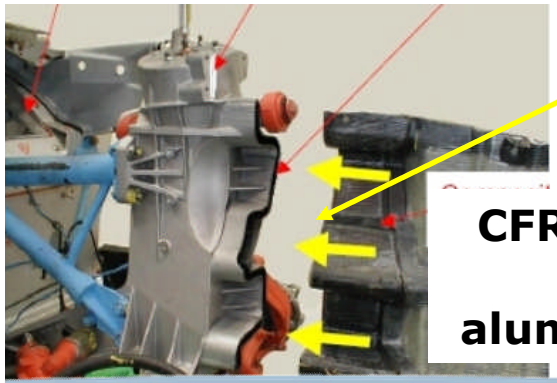
2002: Aston Martin Vanquish ~ 15 Liter Adhesive



SMC-Side panel



CFRP-transmission tunnel bonded to the aluminum body structure



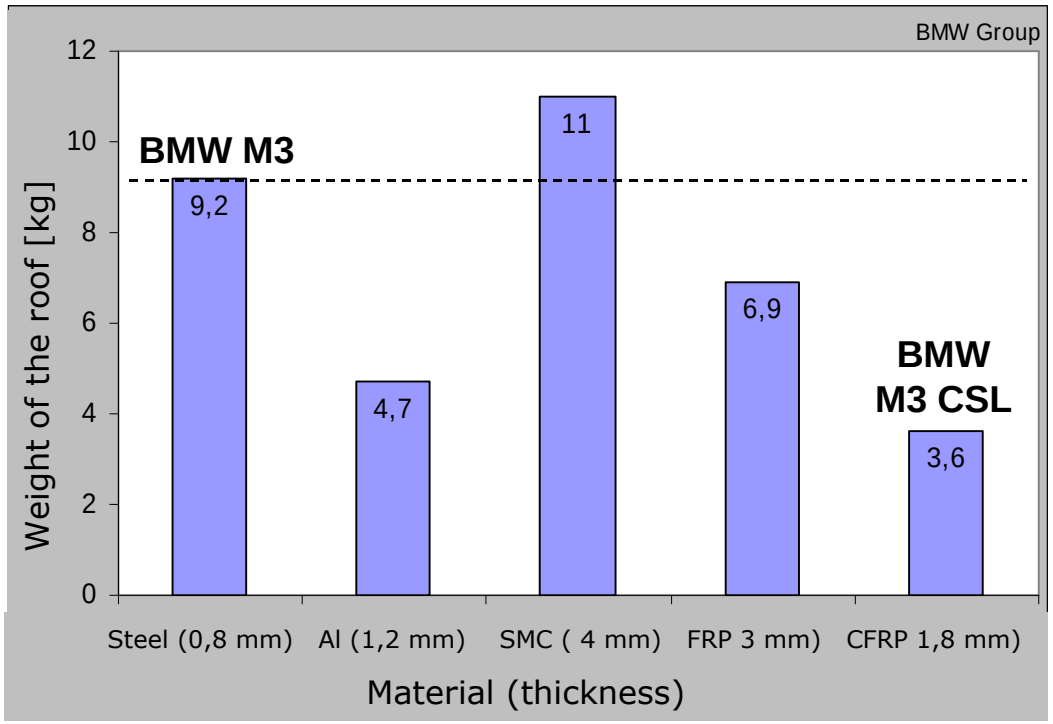
CFRP-Crash structure bonded to cast aluminum strut towers

Source: J. Hill, Automotive Circle International Bad Nauheim 2002

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

2004: BMW M3 CSL – CFRP-Roof, bonded to the body structure
Today : Standard for all BMW M-models



Source: R. Haider, H. Lohse - Adäsion 12/2004

$\Delta m = 5{,}6$ kg

Weight reduction and improving center of gravity

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

Material:

Combination of different materials

(e.g. thermoset/thermoplastic, plastic/metal, …)

Integration of additional functions:

e.g. tightness, therm./electr. conductivity, sound dampening, …)

Bonding – a next generation technology

Processing:

Maintaining material properties

(e.g. surface, no thermal defects, stress distribution to a large area, …)

Construction/Design:

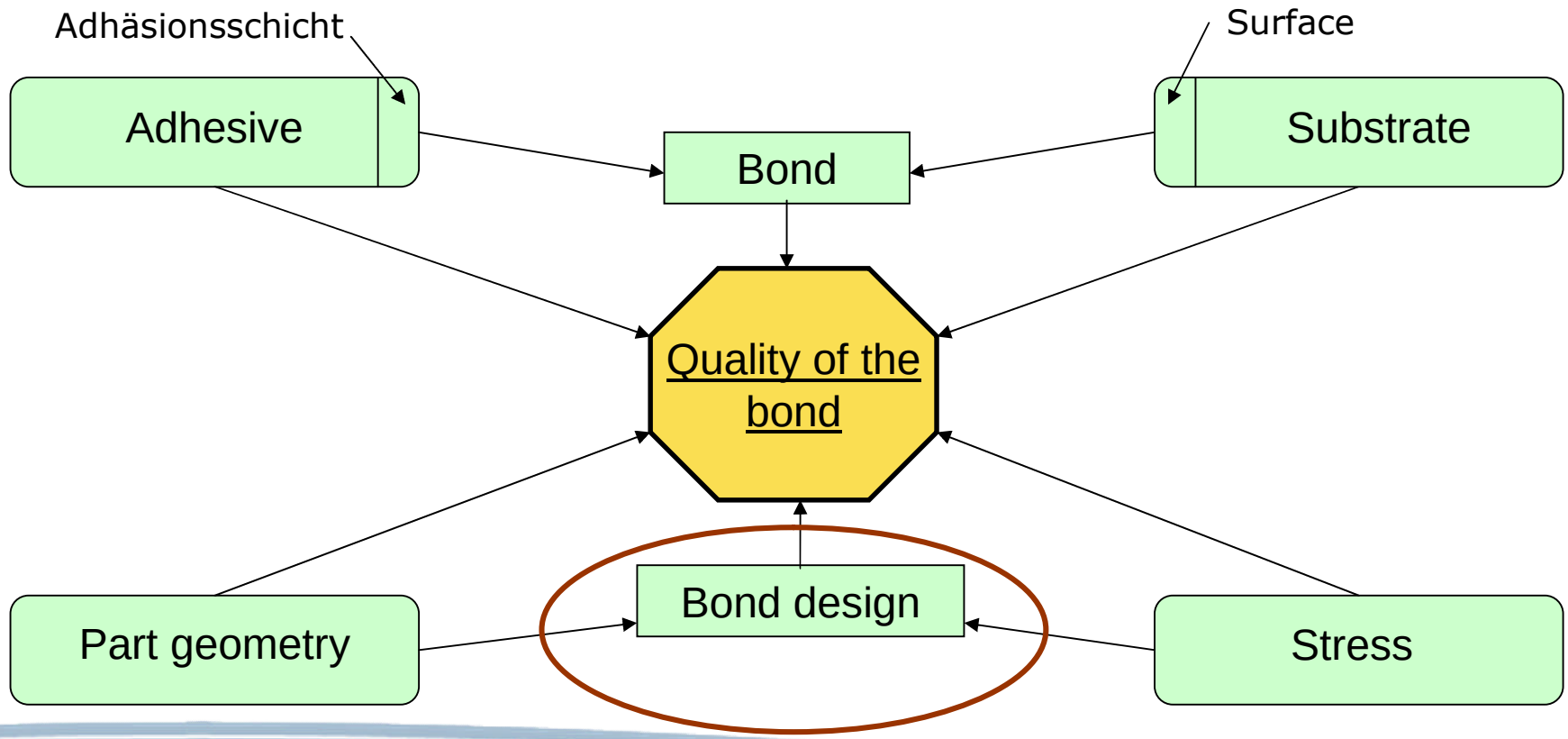
Improved part performance

(e.g. weight reduction, stiffness, design opportunities, …)

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

Factors determining strength and durability of a bond

according to: G. Habenicht, Kleben – Grundlagen, Technologien, Anwendungen, Springer Verlag, 4.Aufl.



© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

Due to it's interdisciplinary character a successful introduction of adhesive bonding into production requires a close cooperation between all involved parties and a competent project management.

This is the only way to assure that all parameters fit together.

- Material properties
- Surface preparation
- Part-handling
- Cycle time
- Tolerances
- Volume
- Application technology
- Cure condition
- Adhesion

- Form of the adhesive
- mechanical properties
- chemical resistance of the Adhesive
- EH&S
- Quality assurance
- costs
- etc.

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

Equipment supplier

Adhesive supplier

Material supplier

Customer

A competent, experienced project management is required to avoid that at the end one piece is missing in puzzle.

Part supplier

‚legislative body'

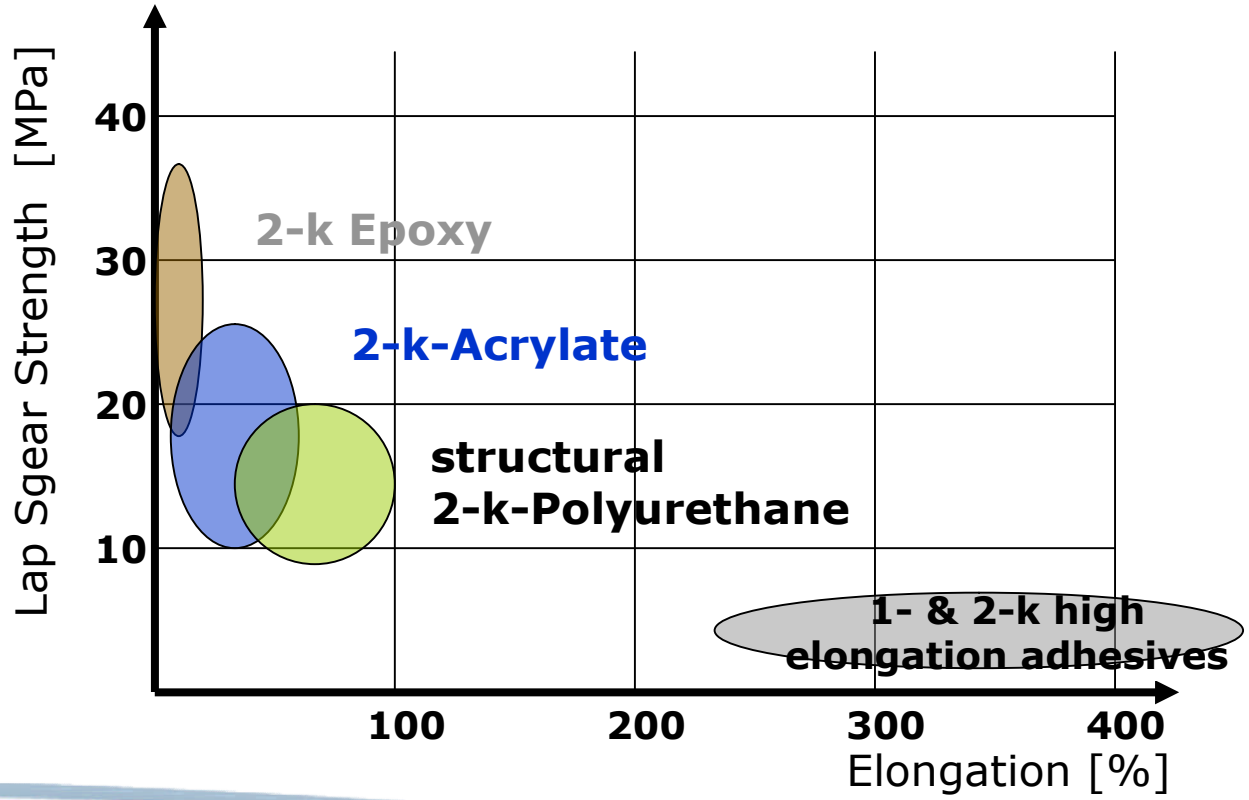
Adhesive user

(external Consultant)

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

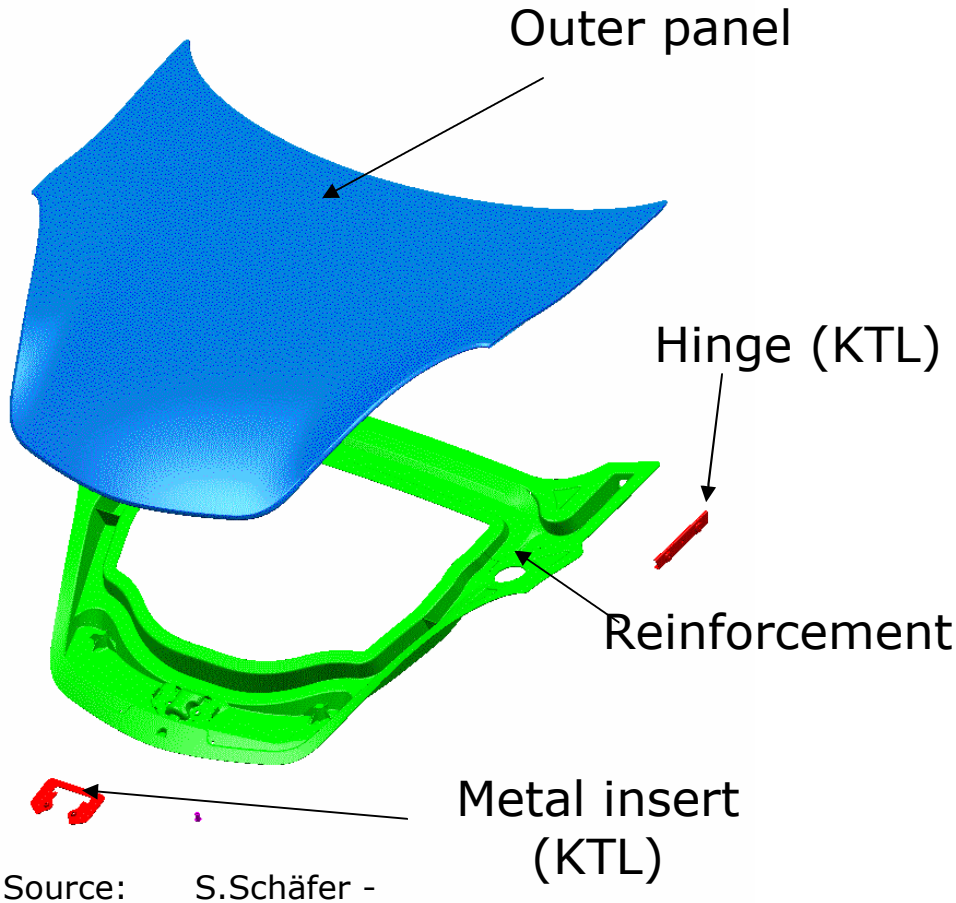
Adhesives in use for composite bonding



© KLEBTECHNIK Dr. Hartwig Lohse e.K.

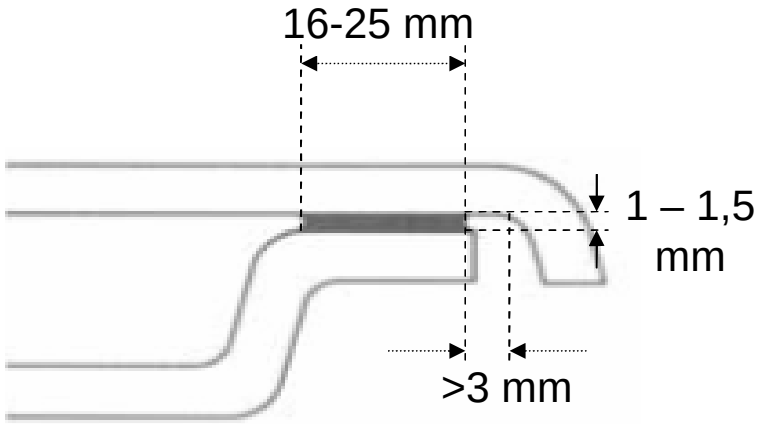
Bonding of Composite Materials in Automotive Engineering

Bond line design



Source: S.Schäfer -
European Alliance for SMC, Bremen 2004

Example: Fronthood

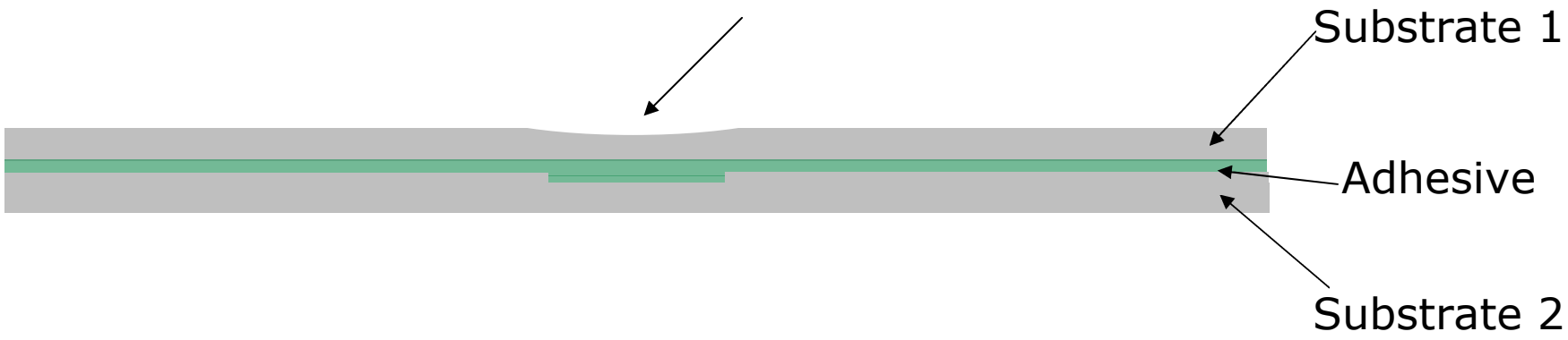


© KLEBTECHNIK Dr. Hartwig Lohse e.K.

Avoiding Bond Line Read Through (BLRT)

Besides the mechanical properties of the materials to be bonded the following has to be considered:

- **Use of adhesives with low shrinkage**
- **Maintain constant joint thickness**



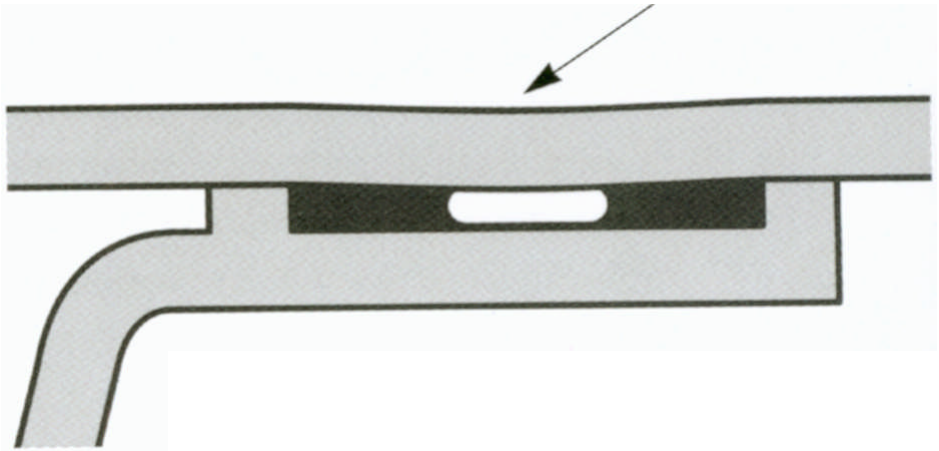
© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

Avoiding Bond Line Read Through (BLRT)

Besides the mechanical properties of the materials to be bonded the following has to be considered:

- Use of adhesives with low shrinkage
- Maintain constant joint thickness
- **Avoid molded-in spacers**



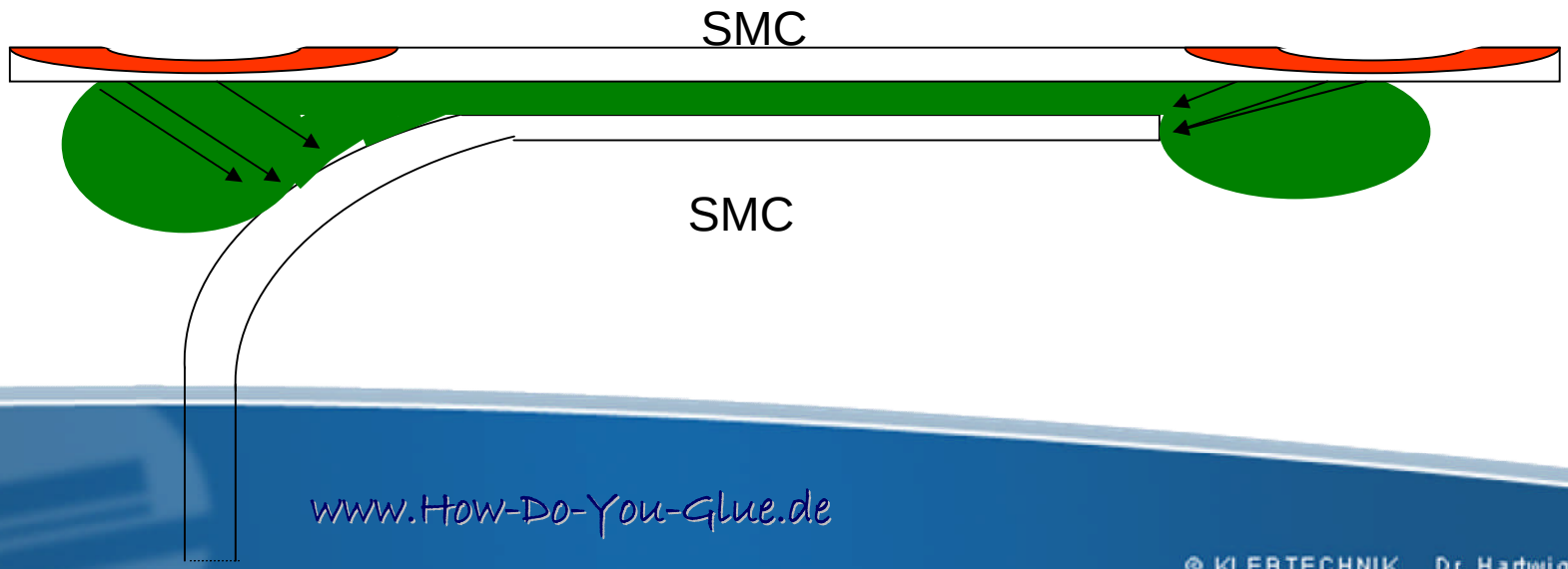
© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

Avoiding Bond Line Read Through (BLRT)

Besides the mechanical properties of the materials to be bonded the following has to be considered:

- Use of adhesives with low shrinkage
- Maintain constant joint thickness
- Avoid molded-in spacers
- **Avoid adhesive squeeze out**



© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

Avoiding Bond Line Read Through (BLRT)

Besides the mechanical properties of the materials to be bonded the following has to be considered:

- Use of adhesives with low shrinkage
- Maintain constant joint thickness
- Avoid molded-in spacers
- Avoid adhesive squeeze out
- **Avoid stress resulting from different thermal elongation**
- **Assure constant cure conditions**

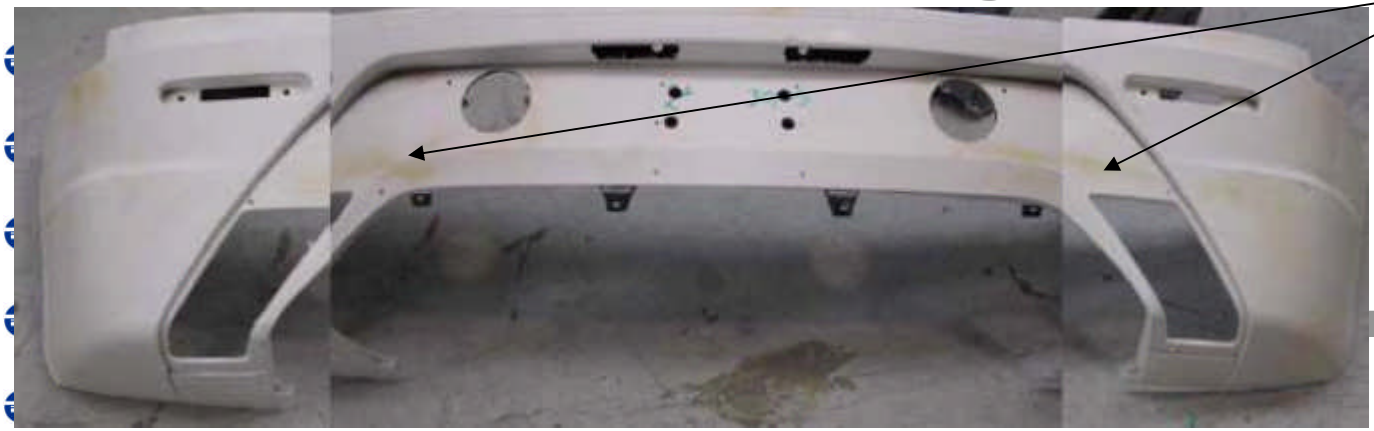
© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

Avoiding Bond Line Read Through (BLRT)

Besides the mechanical properties of the materials to be bonded the following has to be considered:

- Use of adhesives with low shrinkage



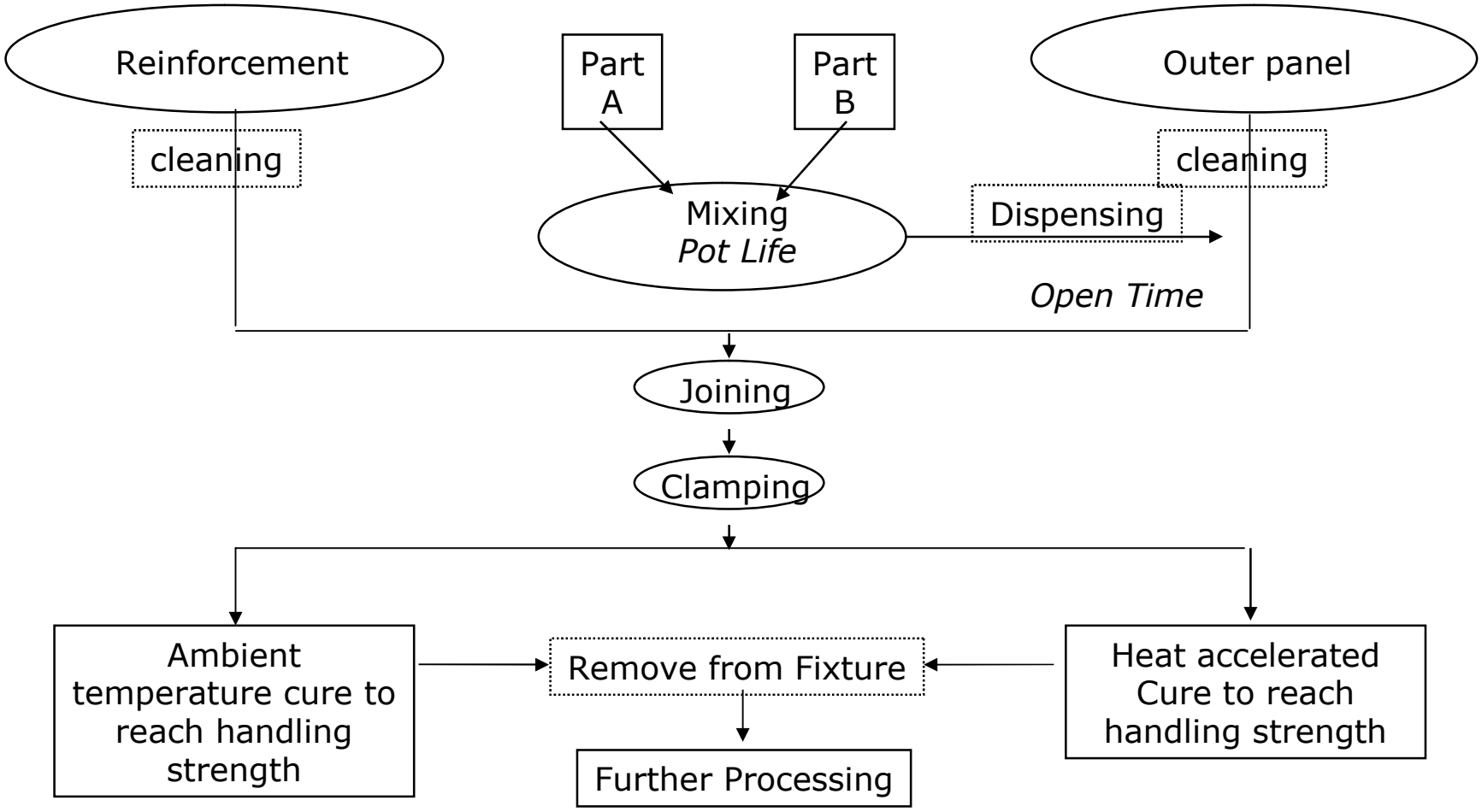
ngation

- **Avoid a thermal damage of the surface as a effect of a too high cure temperature**

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

Bonding of Composite Materials in Automotive Engineering

Bonding process



© KLEBTECHNIK Dr. Hartwig Lohse e.K.

Bonding of Composite Materials in Automotive Engineering

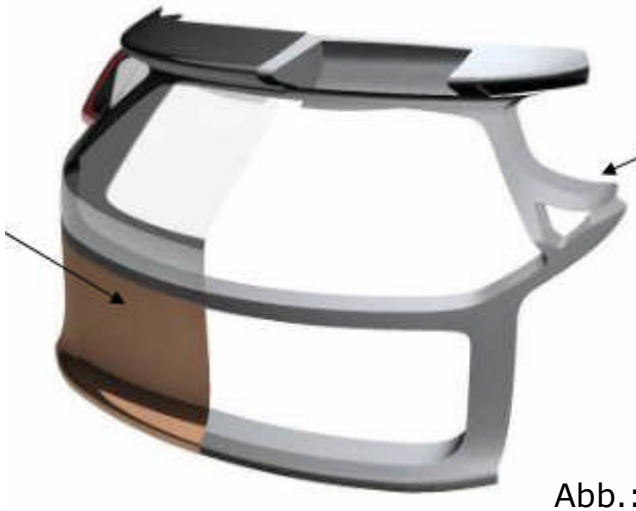
Bonding process

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

Hybrid – Liftgate

Thermoplastic outer panel

(PP/EPDM, ABS, ABS/PC, etc.)



SMC reinforcement

A first car with a hybrid lifgate will be launched at the Paris Autoshow 02. – 17. Oct. 2010

Abb.: ICCT

A ICCT proposal is mentioning magnesium as material for the reinforcing part. Based on experience from VW's Lupo-based 3-Liter-vehicle, showing problems with corrosion protection of magnesium (costly to achieve) a SMC reinforcement has been considered for a new model being introduced to the market this year.

Novel adhesives with special properties, mainly in regard to BLRT, good adhesion to thermoplastics as well as SMC and good low temperature cure properties are required.

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

KLEBTECHNIK
Dr. Hartwig Lohse e.K.
How Do You Glue

Use of Carbon-Fiber-Materials

- **Carbon-Fiber-SMC for closures, e.g. Porsche 911 GT3 II**

  SMC outer panel, C-SMC reinforcement

  →1,3 kg weight reduction compared to SMC/SMC

- **CFRP Body and Body parts, e.g. Tesla Roadster**

  High performance electric sports car
  (288 PS - 212 km/h – 3,7 sec 0 – 96 km/h)
  Epoxy- und Polyester- carbon fiber body panels in conjunction with an aluminum monocoque chassis

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

Use of Carbon-Fiber-Materials

- **BMW MEGACITY CAR –**

  First volume-produced vehicle with a passenger cell made from carbon fiber materials – SOP 2013

  The light weight concept allows to practically offset the extra 250-350 kg of weight typically found in electrically powered vehicles.

  2 horizontally separated modules

  - **Drive Module: aluminum chassis as solid foundation integrating the battery, drive system and basic crash functions**
  - **Life Module: high strength light weight CFRP passenger cell**

© KLEBTECHNIK Dr. Hartwig Lohse e.K.

Many Thanks For Your Attention

Questions?

Dr. Hartwig Lohse

Klebtechnik Dr. Hartwig Lohse e.K.
Fraunhoferstr. 3
25524 Itzehoe
Tel.: +49 4822 95180
E-Mail: hlohse@hdyg.de

© KLEBTECHNIK Dr. Hartwig Lohse e.K.