Lean Exterior Brazing - a pre-study

KEEX ("Kostnadseffektiv Exteriörlödning, en förstudie")

Final Report June 28th 2011 – Vinnova Dnr 2010-01333

Authors:
Kjell-Arne Persson
Joakim Hedegård
Torbjörn Ilar
Lars-Erik Svensson

Table of Contents

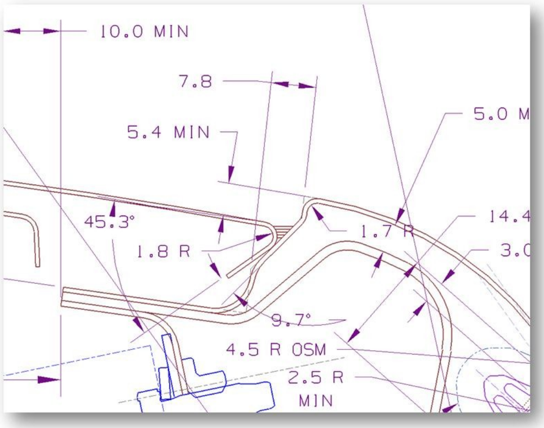
Background

It is important for Swedish vehicle industry to continuously improve manufacturing processes to strengthen the compatibility and to keep production in Sweden. This pre-study was aimed at lowering the cost for joining exterior joints on vehicles, especially joints to the roof.

There are several methods to join the roof to the body side. In common are, for most of these welding or brazing methods, that they require a costly post sealing with a sealing compound and in many cases also use of a cover strip.

Some car producers use laser brazing for the roof to body side joining. This joint will be exterior visible. Therefore the demand on surface finish of the brazed joint is very high but on the other hand sealing or cover strips can be avoided. The investment cost and running cost are however considered high. There are also very high demand on tolerances, in particular positioning of the filler metal is critical.

In this pre-study the possibility to replace laser brazing with conventional or newly developed arc brazing processes should be investigated. It is assumed that the production cost can be lowered considerably with these methods, due to much lower investment cost, provided that the quality becomes comparable to that of laser brazed joints.



Roof

Laser braze

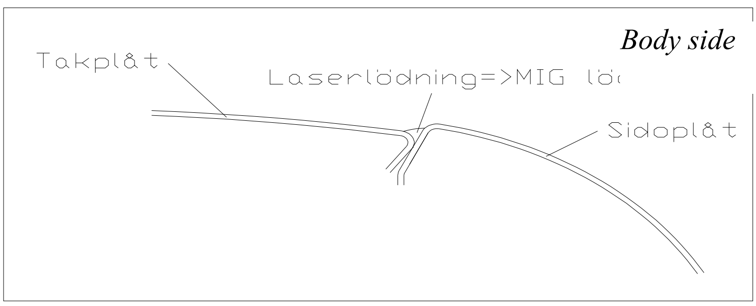


Figure 1 Typical design of a joint between the roof and the body side to be laser brazed.

Figure 1 shows, schematically, a laser brazed joint between the roof and the body side.

Main demands on the joint quality are:

- No defects that affects painting or mechanical strength (no surface breaking defects since accumulation of liquid residues may lead to blistering of the lacquer in the painting line, no lack of fusion, etc.)
- Even and aesthetically appealing joint surface
- No spatter on adjacent areas
- No post work of the braze before painting
- No distortion (low heat input)
- High enough productivity (depends on application, for the roof to body side a minimum travel speed of 2m/min is required)
- Sufficient strength (depends on application)

Objective

This pre-study aims at investigating the possibility to replace expensive laser brazing, in a joint similar to the one shown in figure 1, with conventional or with some newly developed arc brazing processes. It is assumed that if similar quality and productivity can be achieved, as in laser brazing, then a considerable cost reduction should be possible due to a lower investment cost.

Main objective:
Identify one or more arc brazing processes that fulfils the quality demands on laser brazed joints, see the list above.
The minimum required travel speed is 2m/min. Demands on mechanical strength is not yet decided.

Activities:

- Identify suitable alternative brazing processes and filler metals through a state-of-the-art study.
- Design a simplified joint that will indicate the quality level that can be reached with the alternative brazing methods.
- Design and manufacture a fixture suitable for the selected joint and brazing processes.
- Perform tests with the alternative brazing process and compare with existing laser brazing.
- Evaluate the most promising brazing processes
- Propose an extended study of the most promising brazing processes to cover full scale application trials (tolerance boxes, automation aspects, Demonstrator, running cost, etc)

Results

Selected processes and filler metals
4 representative processes of interest have been identified:

- EWM ColdArc. A relatively new MIG brazing process using advanced arc regulation for reduced spatter levels and low heat input. Equipment is available at Swerea KIMAB
- Fronius CMT and Fronius CMT advanced. Relatively new MIG brazing processes using advanced wire feeding and advanced arc regulation for reduced spatter levels and low heat input. Equipment is available at Volvo Cars and at Axson
- EWM forceTIG. A very newly developed TIG brazing process with high energy density due to extreme cooling of the electrode. Equipment is available for testing at EWM in Mündersbach, Germany
- Inocon Plasmatron. A relativiely new TIG brazing process with high energy density due to converging gas flow. Equipment is available for testing at Inocon in Attnang-Puchheim, Austria.

The two MIG brazing processes use specific arc stability control to reduce spatter and to keep heat input low to minimise distortion. However productivity is limited by the maximum deposition rate, i.e. maximum feed of filler metal. Use of low heat input may result in rougher joint appearance compared to conventional MIG processes. A cold melt has lower fluidity which can affect joint geometry and also joint topography. Increased heat gives potential for a smoother joint but may also result in unacceptable distortion.

The TIG processes are by nature very stable and by focussing the arc the power density is increased resulting in travel speeds comparable to or even higher than with laser brazing.

Four different brazing filler metals of interest have been identified:

- CuSi3Mn1, the most frequently used filler metal for brazing in the automotive industry.
- CuAl5Ni2, suitable for high strength applications (DP600 level is stated).
- CuAl8, gives very good visual appearance
- CuSn12P, has a low melting point but uncommon in automotive applications.

Simplified joint and fixture
A simplified joint configuration, suitable for testing, was decided, see figure 2.

Three identical fixtures are produced. One was used by Swerea KIMAB, one by the University West and the third by Volvo Cars.

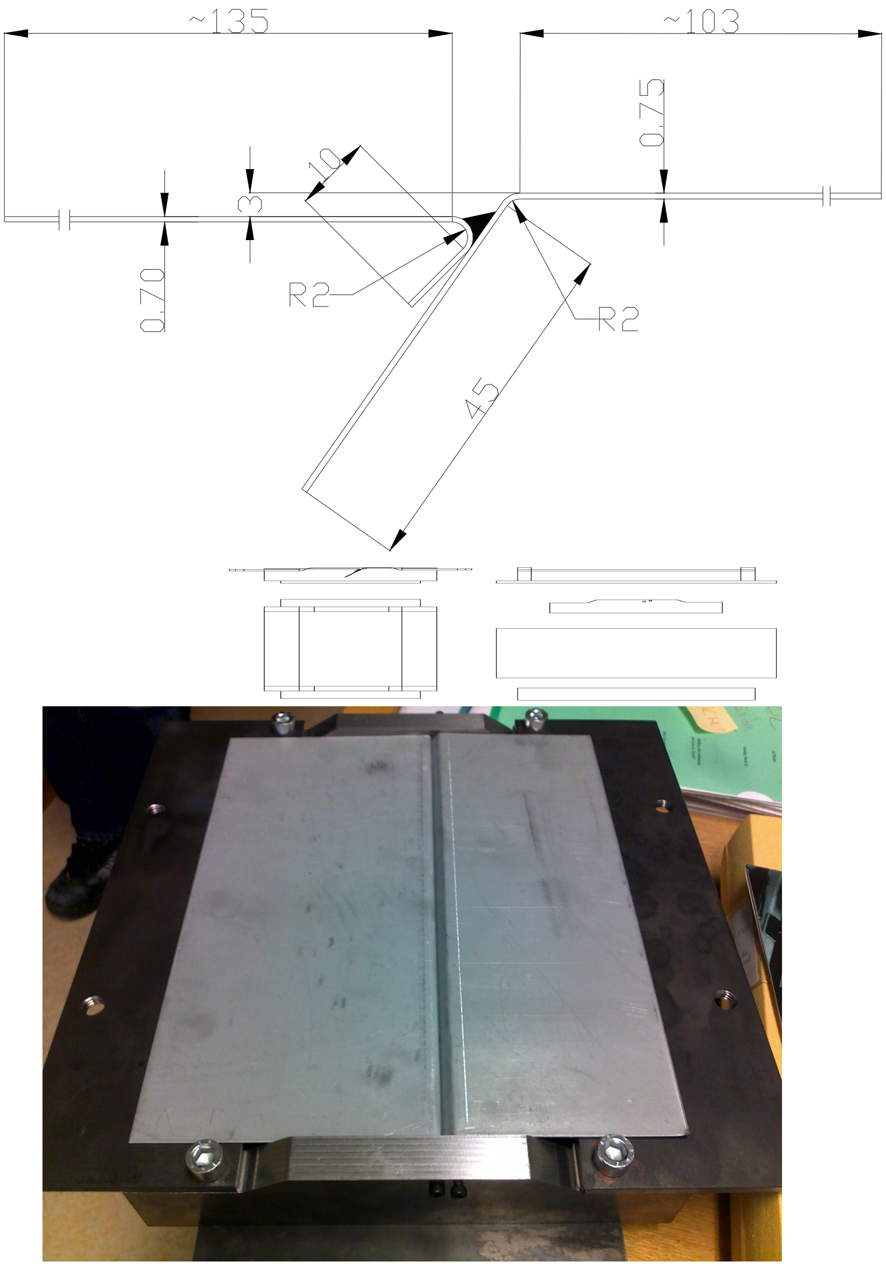


Figure 2 Joint design and fixture for the tests.

Material specification

The length of the plates is 300mm. The roof plate (to the left in the figure 2) is a 0,7mm thick DC04 ZE75/75. The body side plate (to the right in figure 2) is a 0,75mm thick DC05 with 6µm zinc coating on each side.

The typical chemical composition of the filler metals is shown in table 1 and the mechanical strength of pure braze metal is shown in table 2.

Filler metal Type	Filler metal Designation	Cu	Si	Mn	Ni	Al	Sn	Fe	P	Other
CuSi3Mn1	Autrod OK 19.30	Bal.	3.0	1.0			<0.2	<0.3		
CuSi3Mn1	UTP A384	Bal.	2.9	1.0						
CuAl5Ni2	UTP A3421	Bal.		0.2	2.0	5.0				<0.5
CuAl8	Autrod OK 19.40/UTP A34	Bal.		<0.5	<0.5	8		<0.5		
CuSn12P	UTP A320	Bal.					12	<0.1	<0.35	

Table 1 Typical chemical composition of filler metals in wt% [data from filler metal supplier].

Filler metal Type	Tensile strength R_m MPa	Yield strength $R_{p0.2}$ MPa	Elongation A_5 %	Hardness	Melting interval ºC	Toughness J
CuSi3Mn1, Autrod OK 19.30	300	160	23	99 HV	~910-1025	25
CuSi3Mn1, UTP 384	350	120	40	80 HB	965-1035	
CuAl5Ni2, UTP A3421	350		45	84 HB	1060-1085	161
CuAl8, UTP A34	400	180	40	126HB	1030-1040	~70-100
CuSn12P, UTP A320	300	140	25	150 HB	825-990	~8

Table 2 Mechanical strength of pure braze metal (Approximate values at room temperature)[data from filler metal suppliers, ESAB, UTP and Bedra].

Equipment specification

Reference with laser brazing

The reference with laser brazing was performed by Volvo Cars, Gothenburg
The welding equipment used was:

- 4kW lamp pumped Nd-YAG laser
- Wire feeder from Fronius and Fronius wire preheating equipment

A Kuka krc1 robot with a high-YAG brazing head with mechanical seam tracking

EWM coldArc

The tests with EWM coldArc were performed by Swerea KIMAB.
The welding equipment used was:

- Power source EWM Phoenix 521 Progress Puls coldArc
- Wire feed unit EWM Progress Drive 4L

A Motoman HP20 robot has been used for the brazing.
No adaptive control was used.

Fronius CMT

The tests with Fronius CMT were performed by Volvo Cars, Gothenburg and University West.

- Power source Fronius Transpuls TPS4000CMT
- CMT wire feeder and welding torch from Fronius

An ABB IRB 1400 robot has been used.
No adaptive control was used.

Fronius CMT Advanced

The tests with Fronius CMT Advanced were performed by Axson, the Swedish agent for Fronius with participation from University West.

- Power source CMT advanced
- CMT wire feeder and torch

Mechanized welding has been used. No seam tracking.

EWM forceTIG

The tests with forceTIG were performed at EWM in Mündersbach, Germany.
The trials were performed by personnel from EWM and with participation from Swerea KIMAB and Scansonic.
The welding equipment used was:

- EWM forceTIG 1002 was used as power source (a 10-1000A AC/DC TIG power source).
- FocusTIG Drive 4 Rob 3

A special cooler is used to cool the electrode.
A mechanized linear equipment is used for moving the welding torch.
The system is equipped with a tactile seam tracking device, APN1, from Scansonic.

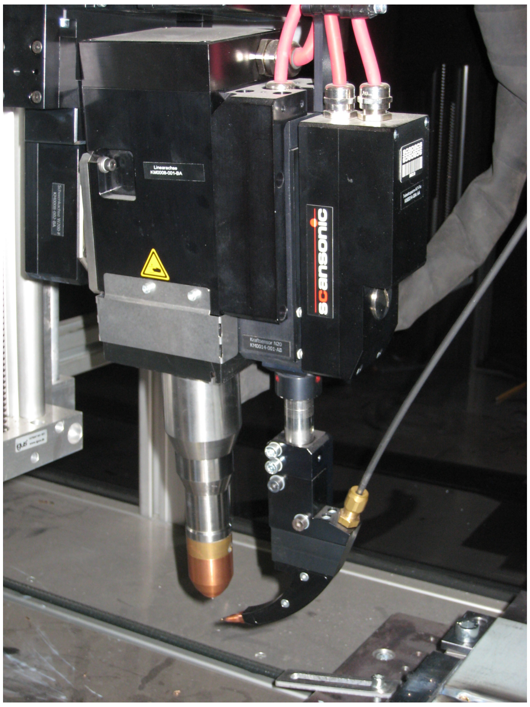


Figure 3 The forceTIG torch and the tactile seam tracking built into the filler wire guide.

Inocon Plasmatron

The tests with Inocon Plasmatron were performed by Inocon in Attnang-Puchheim, Austria.
The trials were performed without participation from the project group.

- Power source Fronius MW5000
- Wire feeder Inocon HDV7001and the Plasmatron torch PTR60-064-900

Mechanized welding
A mechanical seam tracking, Inocon MNV, has been used

Brazing results

Reference, laser brazing at Volvo Cars

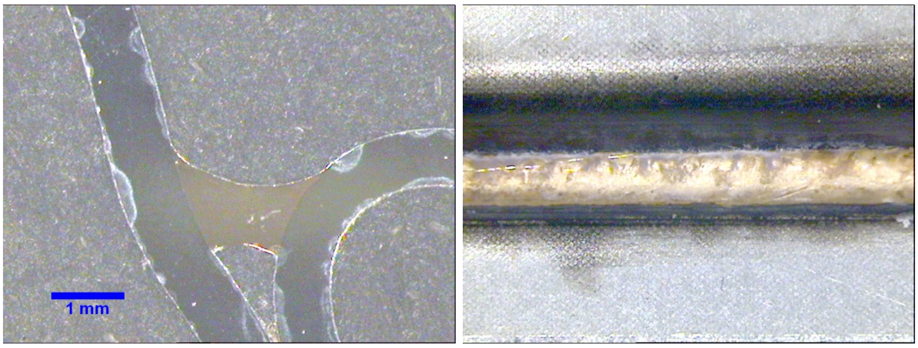


Figure 4 Reference, result with laser brazing and CuSi3Mn1 ∅1.2mm. Travel speed 2.4m/min. Wire feed speed 2.5m/min. Heat input 0.06kJ/mm. No shielding gas.

The travel speed is higher than specified 2m/min. The heat input is low and there is no distortion.
The surface appearance is good with an even surface and the weld toe is straight and regular. There are no visible surface defects and no spatter. Some soot formation can be seen close to the bead.

Results with EWM coldArc

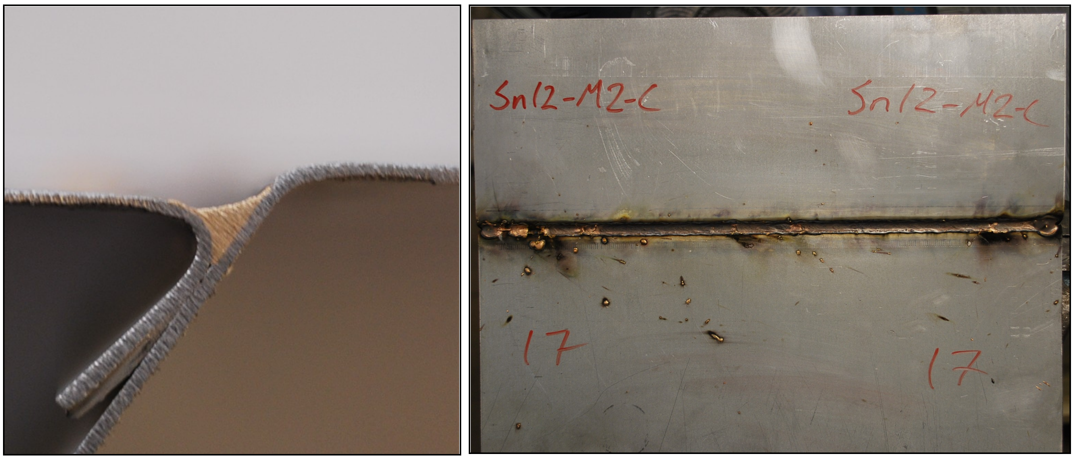


Figure 5 Results with coldArc and CuSn12P ∅1.0mm. Travel speed 1.6m/min. Wire feed speed 8m/min. Heat input 0.06kJ/mm. Shielding gas MISON 2 (Ar+2%CO_2+0.03%NO), gas flow rate 15l/min.

The highest travel speed with fairly acceptable result was 1.6m/min (below specified 2 m/min). There is some spatter but mainly from the start. The surface is a bit uneven and the weld toe a bit irregular.
The appearance can probably be improved with better optimisation but it will be difficult to reach 2m/min in travel speed with acceptable result.

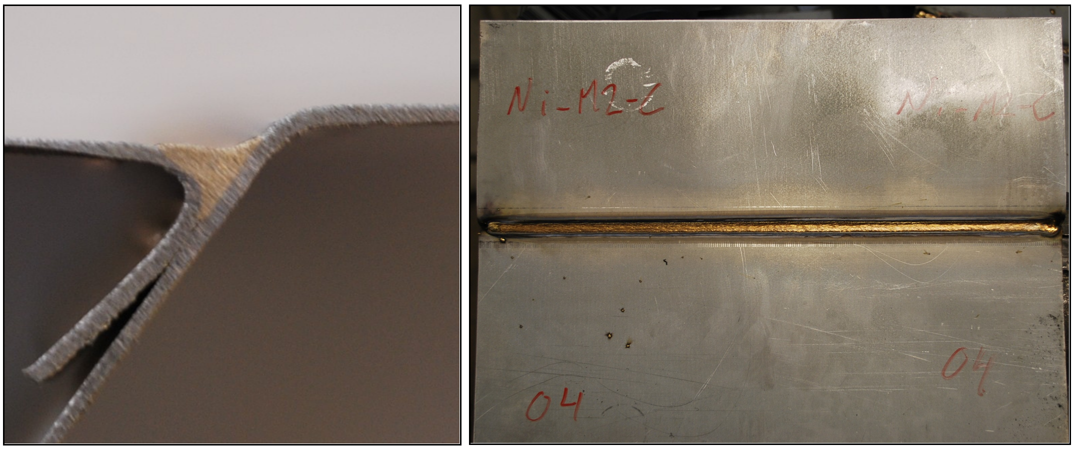


Figure 6 Results with coldArc and CuAl5Ni2 ∅1.0mm. Travel speed 0.8m/min. Wire feed speed 6m/min. Heat input 0.1kJ/mm. Shielding gas MISON 2 (Ar+2%CO_2+0.03%NO), gas flow rate 15l/min.
(In continued tests travel speeds up to 1.2m/min was reached with similar quality.)

The travel speed in the initial test was low, only 0.8m/min (far below specified 2m/min). In later tests the travel speed was increased to 1.2 with acceptable bead appearance but this is still below specified minimum travel speed.
Otherwise the surface appearance is fairly good, relatively even surface and relatively regular weld toe. No visible surface defects but a few spatters from the start.

Figure 7 Results with coldArc and CuSi3Mn1 ∅1.0mm. Travel speed 1.6m/min. Wire feed speed 8m/min. Heat input 0.06kJ/mm. Shielding gas MISON 2 (Ar+2%CO_2+0.03%NO), gas flow rate 15l/min.

With 1.6m/min in travel speed it is difficult to get an acceptable bead with even surface and a regular weld toe. There is also still some spatter.

Even if the MIG brazing with EWM coldArc is not yet optimised some preliminary conclusions can be made:
- The maximum wire feed speed with coldArc synergy-lines differs for the different wires (this is one cause for reaching different maximum travel speeds)
- The CuSi3Mn1wire tends to give spatter, uneven surface and sooting, travel speed up to 1.6 m/min was tested but a continuous braze along the full joint length was not achieved.
- The CuAl5Ni2 wire gives a good appearance but travel speed reached is low, only 1.2m/min

- The CuSn12 wire looks promising regarding a fairly good appearance and a low level of spatter formation. Rather high travel speed was reached, 1.6 m/min but still with some instabilities.

It was noted that the cross section area is large, roughly two to three times the needed compared to the demands. This suggests that the configuration of the joint should be changed towards a smaller radius of the roof plate.

Results with Fronius CMT

Results at Volvo Cars

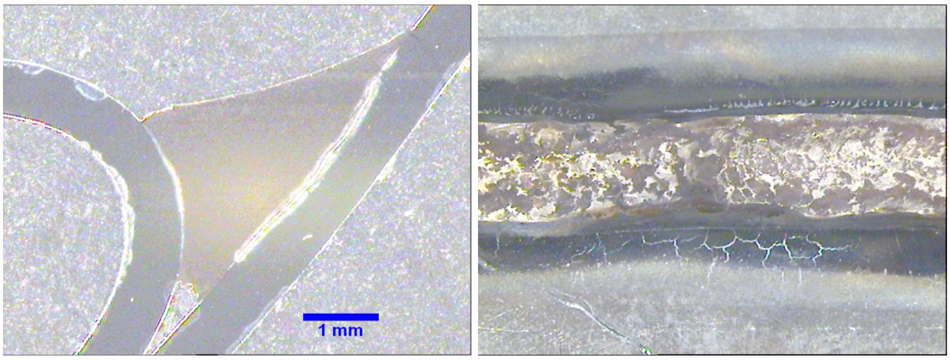


Figure 8 Results with CMT and CuSi3Mn1 ∅1.0mm. Travel speed 0.66m/min. Wire feed speed 3m/min. Heat input 0.06kJ/mm. Shielding gas Ar+18%CO_2.

The travel speed reached in the test, 0.66m/min is far below specified (2m/min). The bead is a bit wavy.

Results at Axson

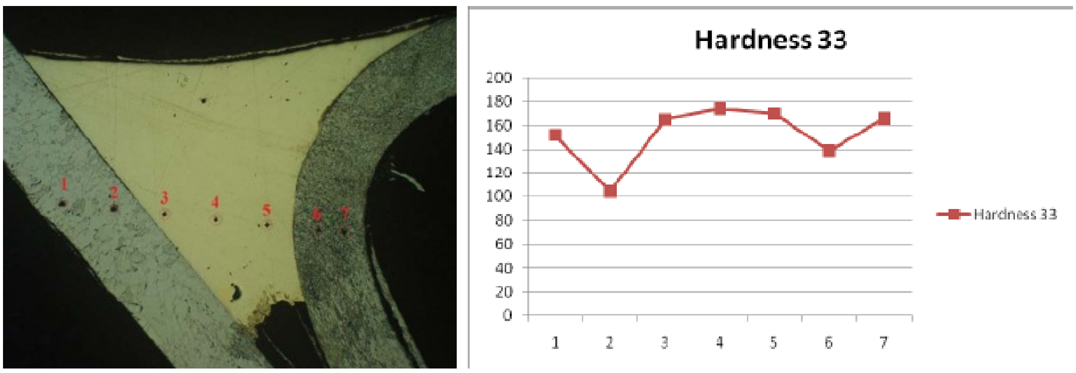


Figure 9 Results with CMT and CuAl8Ni2 ∅1.0mm. Travel speed 1.4m/min. Wire feed speed 7.8m/min. Heat input 0.07kJ/mm. Shielding gas Ar+2%CO_2+0.03%NO, gas flow rate 15l/min.

The highest travel speed reached in the test was 1.4m/min with this filler metal, this is below specified 2m/min.
The quality was also questionable with wavy bead and relatively rough bead surface. Spatters are also generated in the starting phase.

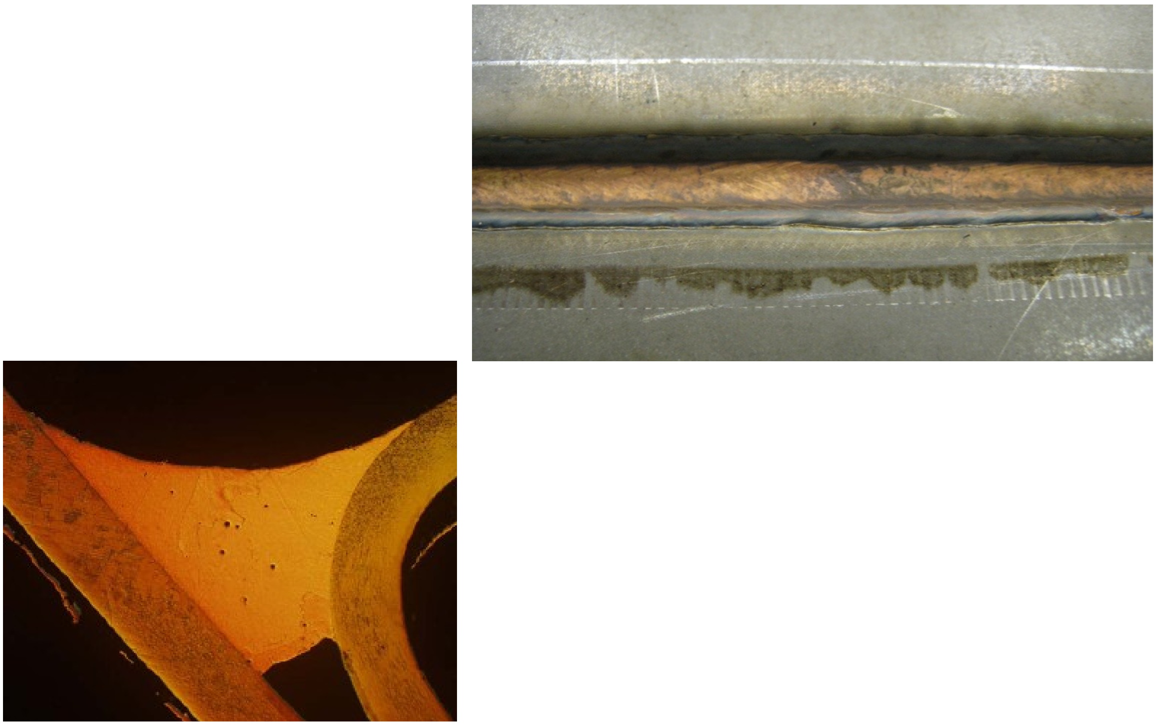


Figure 10 Results with CMT and CuSn12P ∅1.0mm. Travel speed 2m/min. Wire feed speed 7.8m/min. Heat input 0.05kJ/mm. Shielding gas Ar+2%CO_2+0.03%NO, gas flow rate 18l/min.

The highest travel speed reached in the test was 2m/min with this filler metal. This is in line with specified 2m/min.
The surface is even with tiny wave formation at the weld toe. No visible defects but some spatters are generated in the starting phase. This problem can probably be managed with further development of the process parameters.

Results with Inocon Plasmatron

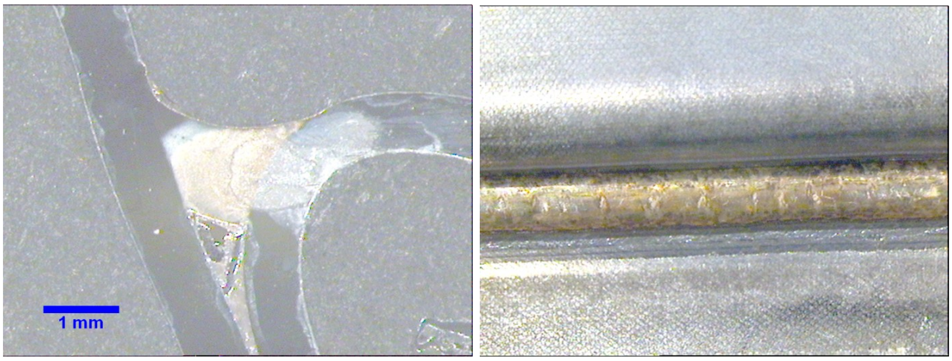


Figure 11 Results with Plasmatron and CuSi3Mn1 ∅1.2mm. Travel speed 2/min. Wire feed speed 1.5m/min. Heat input 0.06kJ/mm. Shielding gas is Ar. The irregular pattern in the cross section is due to the specimen preparation artefact and not due to any defect in the brazing.

The bead appearance is good at the travel speed 2m/min (the travel speed is in line with specified). The surface is even and the weld toe is straight and regular. There are no visible defects and no spatter. Heat input is low and there is no distortion.

Results with EWM forceTIG

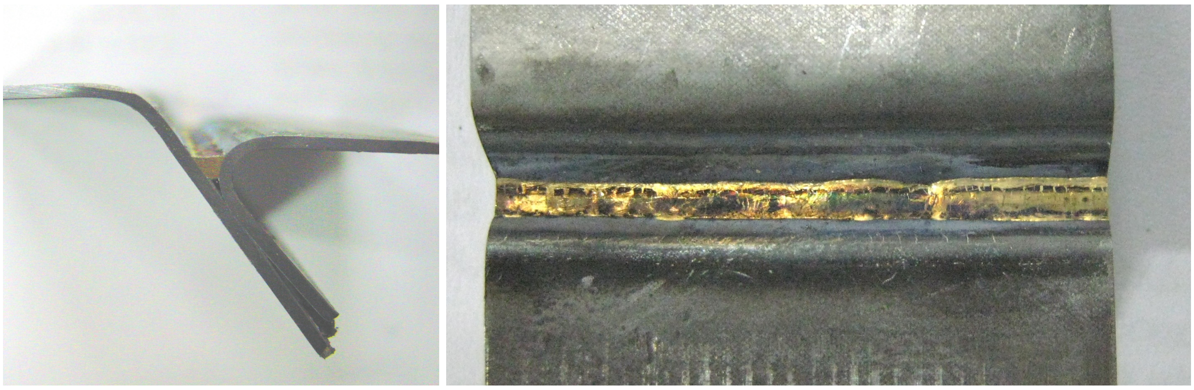


Figure 12 Results with forceTIG and CuAl8 ∅1.2mm. Travel speed 3.0m/min. Wire feed speed 3m/min. Heat input 0.06kJ/mm. Shielding gas Ar. Distance electrode to wire 1.5mm

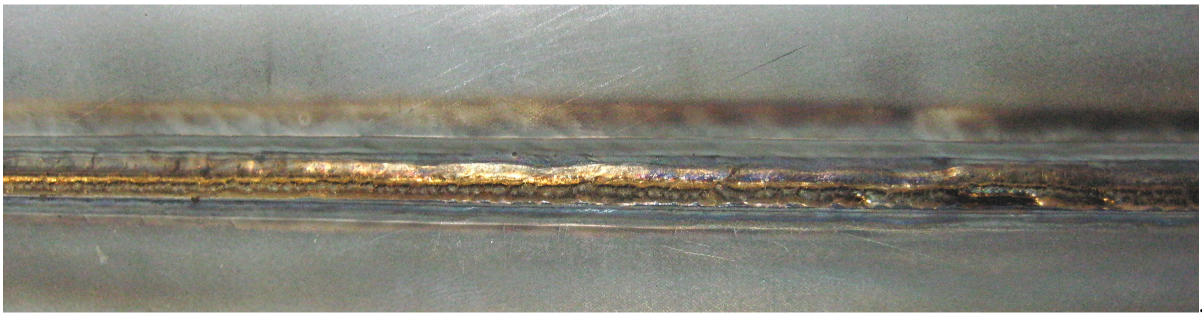


Figure 13 Viewing the full length braze seam, it can be seen that the surface is a bit uneven and there is a skip.

It was not possible, during the short test period, to make a 300mm long braze weld that is even and without any skips at 3m/min in travel speed.

It was however believed that a larger diameter filler wire, not available for these tests, would improve the results. The cross section area of the braze weld is rather small and the distance to the lowest part of the joint becomes a bit long and results partly in that the arc jumps between the roof plate and the body side plate.
If the joint geometry could be changed, so that the radius of the roof part is smaller, giving a smaller cross section of the joint area and less distance to the bottom of the joint, it would be easier to fulfil the demands on the braze weld.

Note: A quick test with slightly modified joint and a filler metal wire with larger diameter, Ø1.6mm CuSi3Mn1, gave very good results, see figure 14.

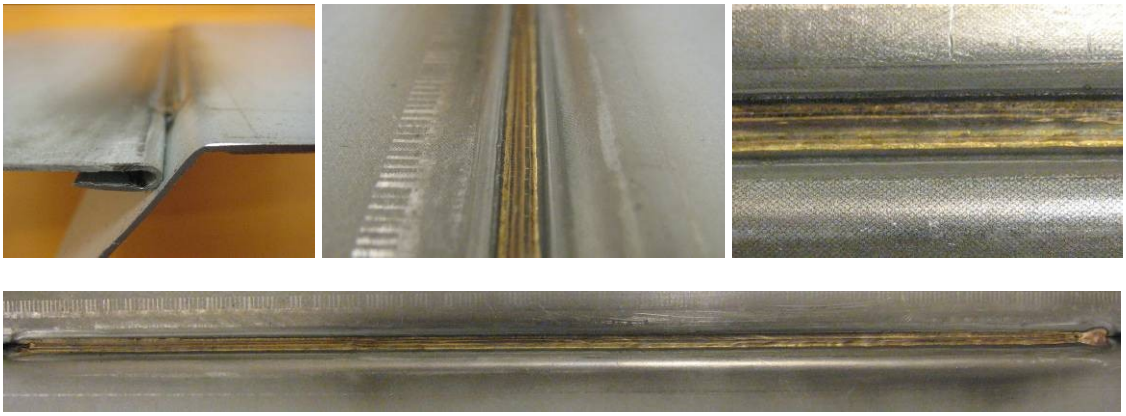


Figure 14 Results with forceTIG and a slightly modified joint configuration and larger filler metal wire diameter, CuSi3Mn1 ∅1.6mm. Travel speed 3.0m/min.

Results from paint test

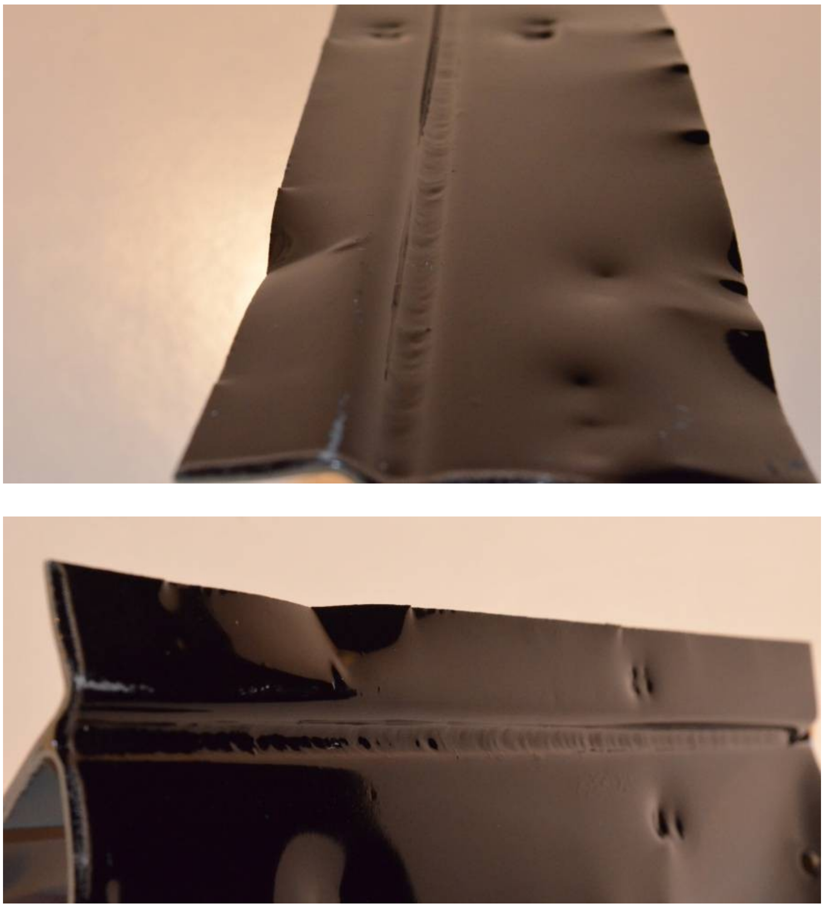


Figure 15 Result from paint test (MAG brazed with ColdArc)

Some selected joints were paint tested. The purpose was to check if the brazed joint could be painted without additional removal of oxides, soot etc. The test would also indicate if there are any surface defects that affect painting.
The selected joints passed the phosphate treatment and the ED (Electro Deposition) and were then manually painted black. The results from the test are positive, but more in-depth tests are needed before any conclusions can be made.
Note! The distortion is due to handling of the sample and not due to the brazing.

Summary of test results

Process	Filler metal	Travel speed m/min	Wire feed speed m/min	Heat input kJ/mm	Comments
Reference Laser brazing	CuSi3Mn1 Ø1.2mm	2.4	2.5	0.06	
EWM coldArc	CuSi3Mn1 Ø1.0mm	1.6	8	0.05	Low travel speed, instabilities and some spatter
	CuAl5Ni2 Ø1.0mm	1.2	6.5	0.07	Good appearance but low travel speed
	CuSn12P Ø1.0mm	1.6	8	0.06	Easier to get good travel speed but further optimisation is needed
Fronius CMT, Volvo Cars	CuSi3Mn1 Ø1.0mm	1	-	-	Low travel speed, irregular weld toe
Fronius CMT, Axson	CuAl8Ni2 Ø1.0mm	1.4	9.5	0.07	Low travel speed, further optimisation is needed for good appearance
	CuSn12P Ø1.0mm	2	7.8	0.05	OK travel speed and appearance is OK
Fronius CMT Advanced	CuSi3Mn1 Ø1.2mm				No results due to stability problems New technique not optimised for this application
Inocon Plasmatron	CuSi3Mn1 Ø1.2mm	2	1.5	~0.05	Travel speed OK, appearance OK
EWM forceTIG	CuAl8 Ø1.2mm	3	3	0.06	Travel speed OK but further optimisation is needed for good appearance Test with a CuSi3Mn1 Ø1.6mm and changed radius at the same travel speed gave very good results

Table 3 Summary of the results from brazing tests.

The most promising processes to replace laser brazing are the two TIG brazing processes, forceTIG and Plasmatron. Both can give very high travel speed and very good brazing result. There are still more optimisation work, tolerance testing and life time of wear parts to be done. Also cost consideration needs to be worked on before the value of replacing laser brazing can be calculated. Cost efficient monitoring & in-ling control need to be evaluated. Other considerations will be torch accessibility (torch size and filler wire guide), need for different fixturing, total cycle time (not only process time), equipment and service availability.
The MIG brazing, here with CMT, could also be interesting for replacing laser brazing but for lower travel speed applications and where the finish of the braze joint is not as critical.

Cost analysis (estimates, very preliminary)

Cost item	**Laser brazing 4kW diod laser**		**forceTIG**		**Plasmatron**		**CMT**	
Investment	Total	Per hour						
Process equipment	Est 300 k€	39.4€/h	Est 55 k€	7.2€/h	Est 75 k€	9.8€/h	Est 30 k€	4.1€/h
Robot, type Motoman HP20	Est 100 k€	13.2€/h	Est 100 k€	13.2€/h	Est 100 k€	13.2€/h	Est 100 k€	13.2€/h
Adaptive control system	Higher than forceTIG		Est 45 k€	5.9€/h	About the same as forceTIG		Same or less than forceTIG	
Additional equipment Wire cutting system Electrode wear analysing			130 k€					
Installation								
Other implementation cost (safety equip. education etc)	?		Less than laser		Less than laser		Less than laser and possibly less than TIG processes	
Fixturing (development, manufacturing and installation)	?		Same as laser		Same as laser		Less than laser	
Maintenance								
Operator cost								
Variable costs	Process idle	Process running	Process idle	Process running	Process idle	Process running	Process idle	Process running
Equipment and operator								
Filler metal Consumption		9.2g 0.09€/m		8.7g 0.1€/m		7.2g 0.07€/m		26.3g 0.37€/m
Process gas Consumption		0 0		3.3 liter 0.02€/m		5 liter 0.04€/m		9 liter 0.06€/m
Power consumption during process incl. cooling unit		0.07kWh		0.03kWh		0.03kWh		0.03kWh
	Total	Per meter	Total	Per meter	Total	Per meter	Total	Per meter
Wear Electrode/contact tube Nozzle Other			25€	0.16€/m Low No		? ? Yes		? ? Yes
Process data Filler metal/diam Wire feed speed, m/min Travel speed, m/min Heat input, kJ/mm Shielding gas flow, l/min Arc time/Cycle time s/s Electrode or torch change, s Braze length between electrode/contact tube change, m	CuSi3/1.2 2.5 2.4 0.06 No gas 24/- - -		CuAl8/1.2 3 3 0.06 10 (Ar) 20/- ?fast 150-400		CuSi3/1.2 1.5 2 0.05 10 (Ar) 30/- <30 ?15		CuSn12/1.0 7.8 2 0.05 18 (Ar+2%CO_2) 30/- <30 >150	

Table 4 Preliminary cost estimates.
Investment cost per hour will depend on depreciation time, annual interest rate and operational time. In the calculated example these are 5 years, 5% and 1760 hours per year (one shift).
Assumed filler metal price CuSi3 10€/kg (density 8.5g/cm^3), CuAl8 12€/kg (density 7.7g/cm^3), CuSn12 14€/kg (density 8.6g/cm^3), shielding gas price 7 €/m^3 both for Ar and Ar/CO_2 mixture (the prices for filler metal and shielding gas are list price rather than actual customer price). Power consumption is based on, for the laser a power efficiency of 35% and a 3 kW cooler, for the forceTIG a power efficiency of 95% and a 1.5 kW cooler, for the Plasmatron a power efficiency of 95% and a 1.5 kW cooler and for the CMT a power efficiency of 90% and a 1.5 kW cooler.

The investment cost is much lower for the arc brazing process equipment than for the laser equipment. EWM states that the investment cost for forceTIG (power source, wire feeder, cooling unit and torch) is about one tenth of the investment for laser equipment.
However, a complete investment would also consist of a robot, seam tracking or adaptive control system and equipment for fixturing.
There is also a cost for installation, implementation and education of operators.

One of the main parts exposed to strong wear due to zinc evaporation is the electrode (the cathode) in Plasmatron and forceTIG.
EWM claims that the electrode has to be changed every 150 to 400m of braze length (mainly depending on thickness of the zinc coating, distance between the electrode and the wire, the current and number of starts). It is stated that replacement of the electrode is fast (no time given), just unscrew the old electrode and replace with the new one. No adjustment of TCP is necessary. The old electrode is waste, can not be grinded.
With Plasmatron the complete torch is changed, Inocon states that this takes less than 30s by manual changing (equipment for automatic change is available with reduced time for changing, about 10s). The electrode is then changed in a workbench in about 3 minutes, including adjustment in a special service unit.

The cost for filler metal should be about the same for laser, forceTIG and Plasmatron for a given joint configuration and probably higher for MIG brazing.

The cost for shielding gas is in the same order as for the filler metal. Laser brazing is however often performed without shielding gas.

The power efficiency is very high for forceTIG and Plasmatron, around 90-95% is claimed. Typical values for MIG/MAG processes are 80-90% and only 5-10% for laser.

Discussion

The aim of this pre-project was to investigate the possibility to replace laser brazing with some arc brazing method, giving similar quality and productivity in terms of brazing speed. From the limited experiments made, the two TIG methods forceTIG and Plasmatron seem most promising. The MIG brazing methods studied did not meet the demands on brazing speed, except for one case. However, there are still many open points that need to be clarified before any final decision can be made. For example, importance of torch position relative the joint, allowable deviation from nominal braze data, mechanical properties depending on selected braze wire, etc. Thus, further investigations of both the process and suitable adaptive control system are needed.

With the MIG brazing methods CMT and ColdArc it was difficult to reach the brazing speed of 2 m/min specified due to problems such as arc instabilities and irregular braze bead with holes (skips). However, with CMT, using a CuSn12 wire the desired speed was achieved. The basic reason for this is not known, but it is presumed that the lower melting point range of the wire helps to increase the flowability and wettability of the melted braze material, so that the brazing speed can be increased. However, this is just a speculation based on very few experiments. Much more investigations are needed to clarify this. If this could be understood from a more fundamental view point, the future development of the process could be made more efficiently and with a higher level of innovation. There is of course also a need to determine the mechanical properties that is achieved with this type of filler metal.

It is also interesting to note that different wires influence properties like oxidation, surface roughness and braze-to-base metal connection. This is however based on subjective judgements so far, and also here more work is necessary if these factors should be understood better. It should be noted that the same influence of brazing wire was not found for the TIG methods, probably because the wire does not constitute a part of the electric circuit, as it is the MIG methods, and the oxidising potential of the shielding gas (argon), is lower than for the MIG methods (Ar / CO_2 mixes).
All methods tested gave a low heat input, nominally the same as laser brazing. In all cases deformation of the sheets was low, supporting the opinion of a low heat input. However, there was a difference in the burn off of the zinc layer on the backside of the joint. Both ColdArc and CMT joints exhibited clear burn off of the zinc layer, while less burn off was seen for the TIG methods and for the laser brazing. This could indicate that the TIG methods and the laser method give different heat distribution in the joint due to a more concentrated arc / beam than the MIG brazing methods. There could of course also be other explanations for this observation, but more investigations are needed to clarify this.

The tendency for skips (holes or areas where the braze metal has not wetted the joint surfaces) noted for the TIG methods seems to be connected to a long distance between the electrode and the bottom of the joint resulting in arc jumps between the joint faces. A quick test indicated that this problem can be overcome by changing the joint configuration, with a smaller radius on the roof plate sheet and by using a larger diameter of the filler metal.

It should be noted that the joint configuration that has been studied is very demanding. Although it seems from this study that the TIG methods should be chosen for a more extensive investigation, it is possible that also the MIG methods, with further optimisation can be an alternative. The advantages of the MIG processes are that the setting of parameters may be less critical and that the demands on fixturing may be lower. Experiences in industry from MIG processes are also larger. The sensitivity of the TIG processes regarding electrode life in a zinc rich environment is another factor which must be considered and evaluated.

The recommendation from this pre-study must be to prioritize the TIG methods for a deeper study, to see if laser brazing can be substituted. CMT could also be used in some cases.

Proposals for further investigations

Some questions that needs further investigation:

- How will a change of heat source, from a laser beam to an arc, influence on joint properties, in particular at high travel speeds? (Risk for painting problems, risk for defects, mechanical strength, corrosion etc.)
- Is the demand on fixturing changed, lower or higher than in laser brazing (varying gaps etc)? What are the demands on an adaptive control system?
- How much are the arc properties changed due to electrode wear (zinc vapours etc.)?
- Could the wear be avoided or how can it be measured and controlled (process monitoring and control)?
- Is there wear of other parts that can cause problems?

- When is there a risk for unstable arc or an arc jumping between different sides of the joint resulting in uneven surface, irregular connection to the plates and in worst case skips or holes)?
- How is a robust arc brazing process best created?
- How should process monitoring & control best be performed?
- Joint properties for arc brazed joints should be investigated
- Can high-speed Brazing be developed so well that it can replace resistance spot welding to a larger extent? This would not only increase productivity but also open process possibilities for more mixed material joints.

Conclusions

The most promising processes to replace laser brazing are the two TIG brazing processes, forceTIG and Plasmatron. Both can give very high travel speed and very good brazing result. The results are, however, not verified (joint strength, suitable process monitoring and adaptive control, robustness, etc).

There are still more optimisation work, tolerance testing and life time of wear parts to be done as well as testing of the mechanical strength of the braze joints. Also cost consideration needs to be worked on before the value of replacing laser brazing can be calculated.
Other considerations will be torch accessibility (torch size and filler wire guide), need for different fixturing, total cycle time (not only process time), equipment and service availability.
The MIG brazing, here with CMT, could also be interesting but for lower travel speed applications and where the finish of the braze joint is not as critical.

To be able to finalise and verify the results, a continued project application has been sent to Vinnova, with the title LEX-B (Lean Exterior Brazing, part-B).

Project participants

Sven-Ove Olsson, SAAB Automobile
Lennart Malmsköld, SAAB Automobile
Johnny K Larsson, Volvo Cars
Joel Lundgren, Volvo Cars
Kjell-Arne Persson, Swerea-KIMAB
Joakim Hedegård, Swerea-KIMAB
Jukka-Pekka Anttonen, Swerea-KIMAB
Torbjörn Ilar, University West
Lars-Erik Svensson, University West
Anna-Karin Christiansson, University West