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Evaluation of the Quality of Hybrid Joints created by Flow Drill and bonding

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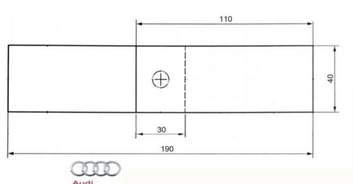
The contribution presents the results of research focused on the creation of dissimilar joints of materials using thermal drilling technology by Flow-drill. The selected materials were: deep-drawn uncoated steel DC04, HSLA zinc coated steel TL 1550 – 220 + Z and aluminium alloy EN AW - 6082 T6. Two types of joints were formed – Flow-drill joints and Flow-drill and adhesive bonding. Surface preparation was used based on organosilane and two adhesives – epoxy and rubber based. Joints underwent corrosion exposition in climate chamber in accordance with the Standard PV1200 (temp ranged from - 40 °C to 80 °C and relative humidity from 30 % to 80 %, 10 cycles totally. Load bearing capacity of joints was tested in tension. The results confirmed the assumption that the use of adhesive in combination with FD significantly increases the load-bearing capacity of the joints due to a much larger contact area. The effect of surface treatment is positive for all tested material combinations, it was manifested by an increase in the load-bearing capacity of the joints by 35 – 73 %. The activation of the contact surfaces increases the adhesion in joints created by FD and adhesive bonding, especially in combination with a rubber-based adhesive.

Base material – chemical composition and mechanical properties

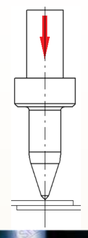
Material wt%	C	Mn	Si	P	S	Al	Nb	Ti	Fe
DC	0.040	0.25		0.009	0.008				balance
TL	0.1	1.0	0.5	0.08	0.03	0.015	0.1	0.15	balance
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
Al	1.0	0.4	0.06	0.4	0.7	0.02	0.08	0.03	balance

Material	Re [MPa]	Rm [MPa]	A80 [%]	Zn layer [g/m²]	r	n
DC	197	327	39.0	-	1.900	0.220
TL	292	373	34.0	104	1.350	0.190
	Re [MPa]	Rm [MPa]	A50 [%]			
Al	295	344	14			

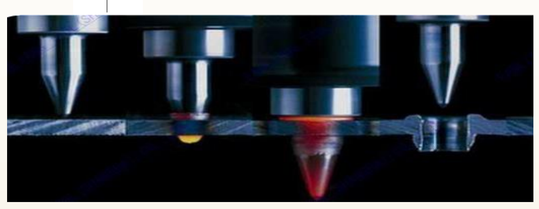
Dimensions of test joints



Flow-drill tool – FD Long 5,3 mm

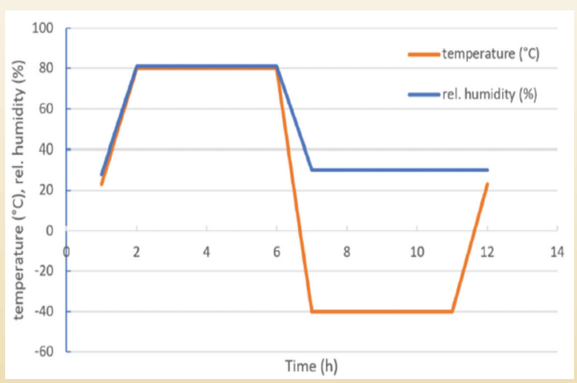


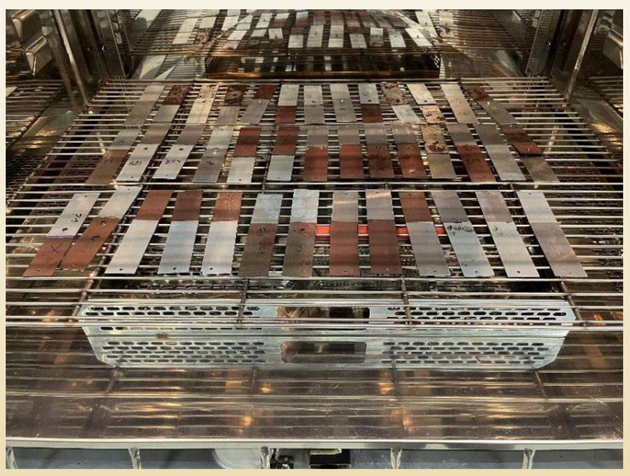
Types of joints in Audi R8 Coupé



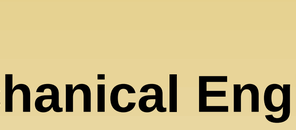
Principe of Flowdrill technology

Corrosion test in climate chamber

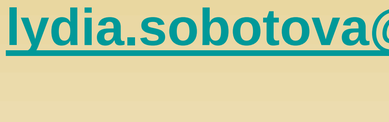




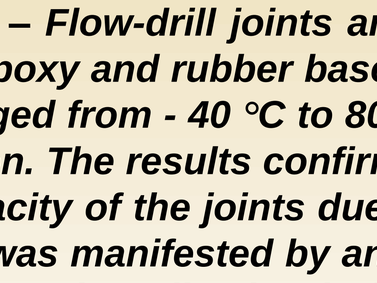
Appearance of joints – metallographic study

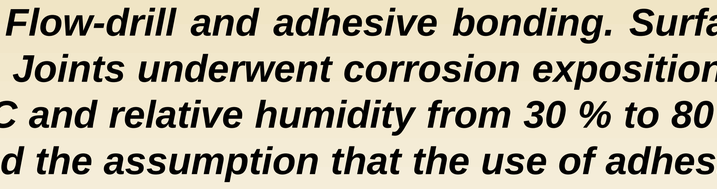


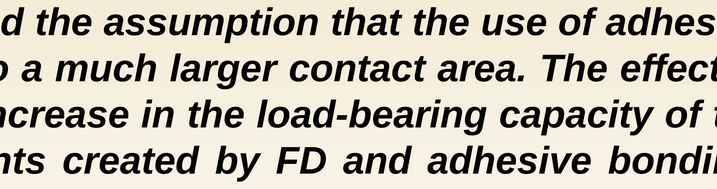
DC-Al joint



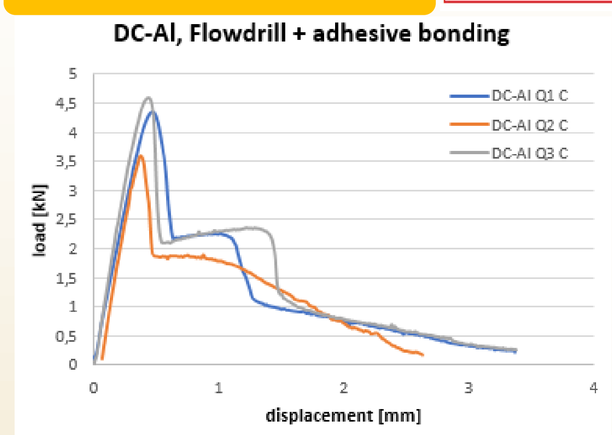
TL - Al joint

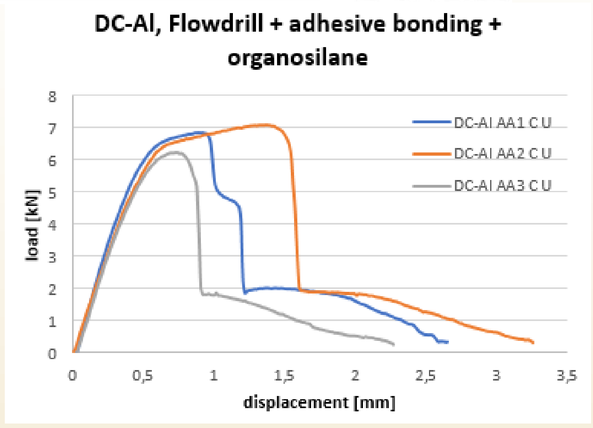


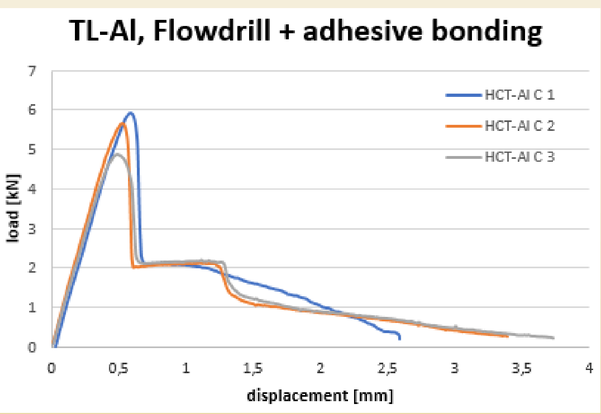


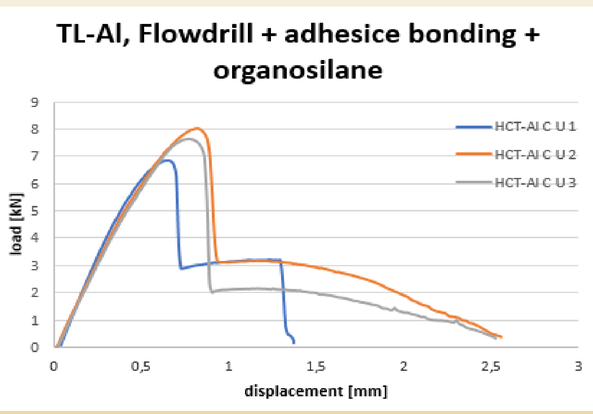


Load bearing capacity of joints









Conclusion

The utilisation of an adhesive in combination with Flow - drilling significantly increases the load - bearing capacity of the joints, because the adhesive acts on a much larger contact surface:

- Teroson EP 5090 adhesive has a higher load capacity than Teroson RB 5197 adhesive,
- the effect of surface treatment when using Teroson RB 5197 adhesive is positive for all tested material combinations, it was manifested by an increase in the load - bearing capacity of the joints by 35 – 73 % ,
- the effect of surface treatment when using Teroson EP 5090 adhesive is positive for TL - Al and TL - DC joints. It was manifested by an increase in the load - bearing capacity of the joints by 10 – 13 %. In the case of the DC - Al joint, on the contrary, there was a decrease in the load-bearing capacity by 6 %. But, the load - bearing capacity of the joints formed with this epoxy adhesive always exceeds the yield strength of the weaker of the two materials to be joined, and the failure of the joints under stress occurs only after significant plastic deformation and strengthening of the substrate.
- the impact of the climate test was negatively reflected in the DC - Al joint with Teroson RB 5197 adhesive, where due to corrosion stress, the bearing capacity was reduced by 72 % in joints without surface treatment and by 22 % in joints with surface treatment,
- in TL - Al and TL - DC joints with Teroson RB 5197 adhesive, the bearing capacity of the joints increased due to corrosion stress,
- the effect of corrosion stress on joints with Teroson EP 5090 adhesive is not clear - cut, in some places there was an increase, in others a decrease in bearing capacity. But again, the bearing capacity of the joints is above the yield strength of the weaker of the two materials being joined, and joint failure under stress occurs only after significant plastic deformation and strengthening of the substrate. From the above findings, it is possible to recommend the use of a product to improve adhesion with Teroson RB 5197 adhesive, it is not relevant for Teroson EP 5090 adhesive. Surface treatment with organosilane also has a protective effect against under - corrosion of adhered joints.

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