

# Experimental and numerical study on bonding of cast aluminium components for the automotive industry

AA Correia | EAS Marques (INEGI, Portugal) | VCBM Rodrigues | RJC Carbas | LFM da Silva

## INTRODUCTION

Modern automotive manufacturing is increasingly reliant on complex cast components to optimize structural weight and performance. To integrate these parts effectively, adhesive bonding has emerged as a critical joining technology, offering superior stress distribution and multi-material compatibility. However, the inherent nature of cast surfaces, which are often characterized by irregular topographies, porosity, and residual mold-release agents. All this frequently results in suboptimal conditions for high-strength adhesion. Furthermore, these bonded assemblies must maintain their integrity in harsh service environments that might lead to early joint failure. This work addresses these challenges by investigating the influence of surface treatments and evaluating the long-term durability of adhesives used in cast-metal applications



Figure 1 – Example of cast aluminum component, with areas for assembly of secondary components (bonded or fastened)

## MATERIALS AND METHODOLOGY

This project analyses the effect of two different adhesive on aluminum-silicon castings. A thermoplastic film adhesive, (LS-XU) was selected due to the ease of disassembly, while a high-performance silicone (TEROSON MS939) was selected to better match industrial practice and due to its sealing capabilities. Multiple surface treatments were considered, such as degreasing, sandblasting and anodization, applied over different substrate surfaces.



Figure 2 – Surface treatments applied on the cast aluminium components.

Testing was carried out using SLJ specimens, cut from cast aluminum components, peel tests and component level internal pressure tests. To simulate exposure to harsh environments, joints were also exposed to hydraulic oil. Numerical simulation was carried out to assess the failure mode of the component and enable its redesign to maximize the performance of the adhesive layer.

## RESULTS

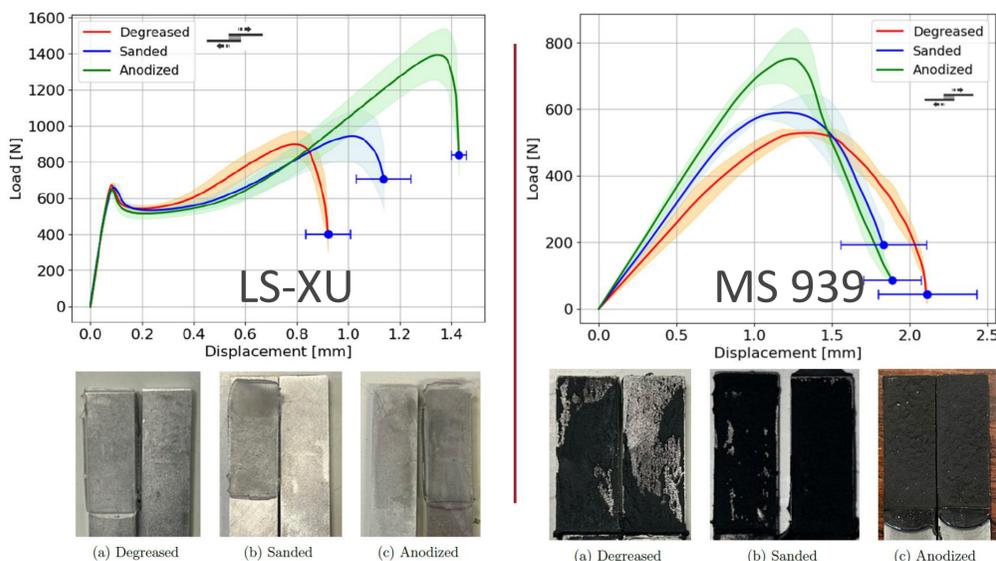


Figure 3 – Joint performance and failure modes for “as cast” specimens with different surface treatments.

As shown in Figure 3, anodized joints exhibited the best performance, with LS-XU, providing the highest failure loads.

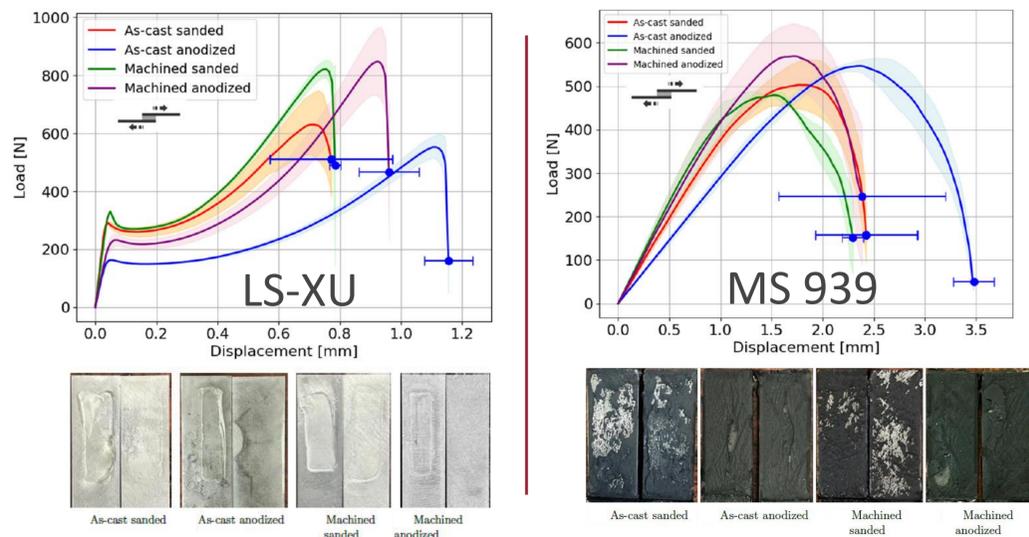


Figure 4 – Response of the adhesive to ageing in hydraulic oil.

A drastic drop in performance is seen in Figure 3 for the LS-XU, which is found to suffer mass loss when exposed to hydraulic oil. This was found to severely limit the practical use of this adhesive for this application.

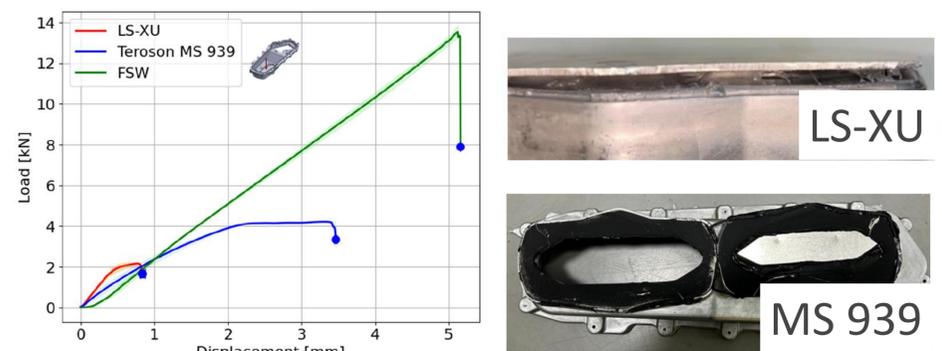


Figure 5 - Comparison of the performance of both adhesives under internal pressure.

Internal pressure testing highlighted the low peel strength of the LS-XU adhesive, which suffered adhesive failure at low displacement, with the MS 939 showing higher performance. At this stage, the performance of the joint was compared with that obtained with friction stir welding (FSW). FSW allowed to obtain significant higher strength, but at a higher manufacturing time and cost.

## MODELLING AND REDESIGN

Modelling of internal pressure testing using ductile damage elements in the metal, allowed to guide a redesign of the part, with a thicker and larger bondline area, better suited for adhesive bonding.

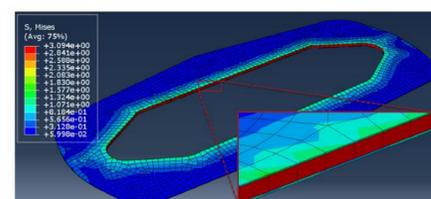


Figure 6 – Stress within the adhesive layer during internal pressure testing)

## CONCLUSIONS

This work demonstrated the usefulness of adhesive bonding for joining cast components, allowing to identify a suitable adhesive (MS 939) and surface treatment, as well as guiding the redesign of the component for bonding.

## ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support provided by WEDRONE for carrying out this work.