# A novel adhesive bonding process for the next generation of wood milling tools

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## Introduction

Adhesives are being introduced in the milling tool industry seeking to replace brazing and mechanical fastening when joining the cutting bits to the tool body [1]. Steel (St) and aluminum (Al) bodies were studied, due to the versatility of steel and the market's preference for lightweight tools, respectively. But the durability of these joints is still a big concern. This work aims to evaluate and characterize the effect of environmental factors associated with the tool's life cycle on the performance of these bonded joints [2].

## Experimental methodology

Several stages of the tool's life cycle can be a source of degradation, as seen in Figure 1.

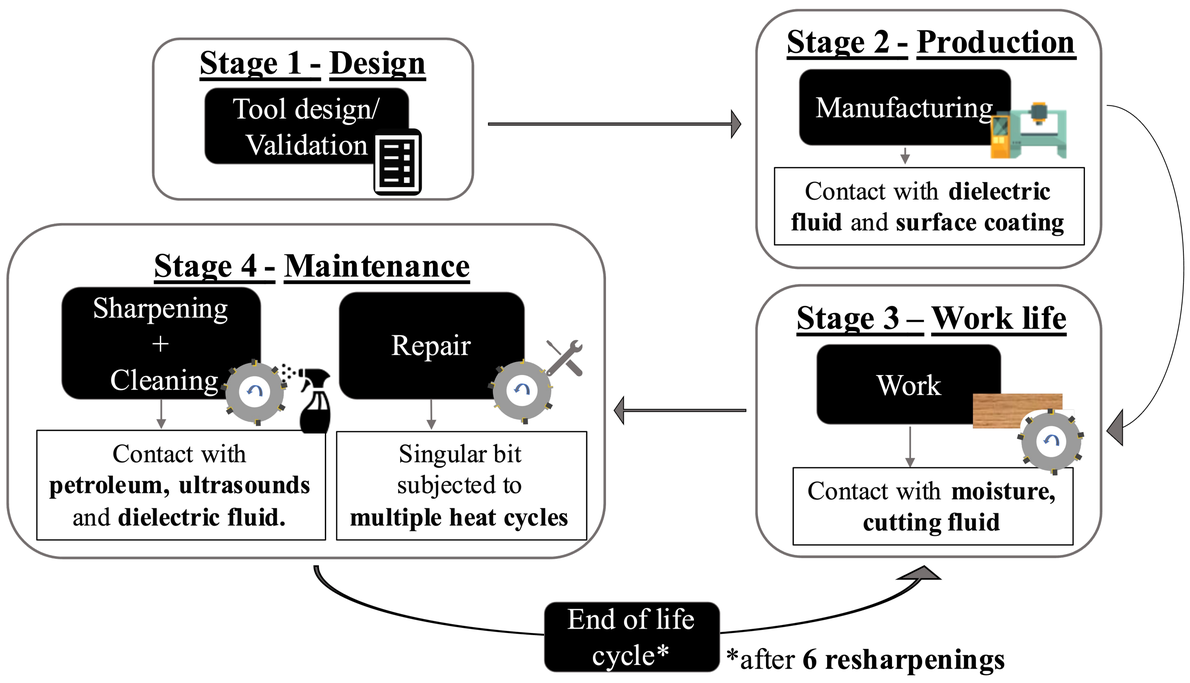


Figure 1 – Typical life cycle of a milling tool [2].

Gravimetric (Grav) and real joint shear (RJS) tests were performed to access the degree of adhesive and joint degradation in each medium, respectively. As such a testing plan, presented in Table 1, was devised to understand this issue in both continuous and cyclic ageing conditions.

Table 1 – Ageing testing plan for each life cycle stage [2].

| Stage 2 | | Stage 3 | |
|---|---|---|---|
| Dielectric fluid (**DF**) | Oxidation (**Oxi**) Nickle-plating (**NiP**) | Water (**W**) | Cutting emulsion (**CE**) |
| Grav/RJS test (**St**/**Al**) | RJS test (**St**) | Grav/RJS test (**St**/**Al**) | Grav/RJS test (**St**/**Al**) |
| **Stage 4** | | | |
| Petroleum (**PO**) | Ultrasound (**US**) | Sandblast (**SB**) | Repair at 150ºC (**Rep**) |
| RJS test (**Al**) | RJS test (**Al**) | RJS test (**Al**) | RJS test (**St**/**Al**) |

## Experimental results

The gravimetric test results can be seen in Figure 2, for water, cutting fluid and dielectric fluid, respectively.

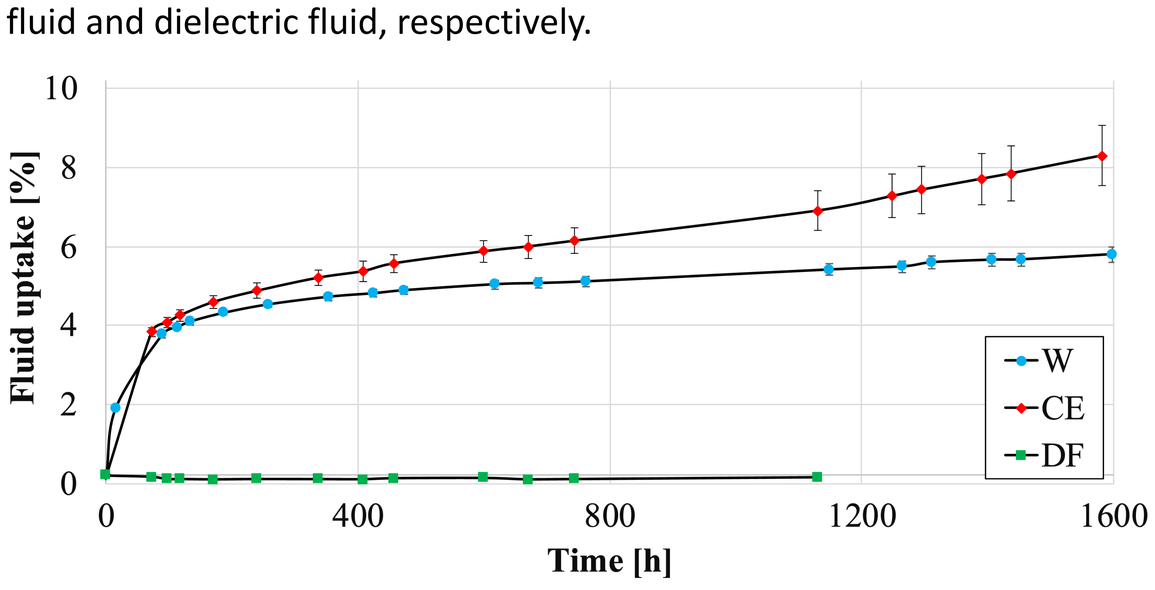


Figure 2 – Experimental results for the gravimetric analysis [2].

Gravimetric analysis on water and the cutting emulsion presented similar behaviors (Dual-Fickian) having, the second, a higher uptake in the relaxation dominated stage.
The dielectric fluid was not absorbed by the adhesive proving that only the first two can damage the adhesive itself.

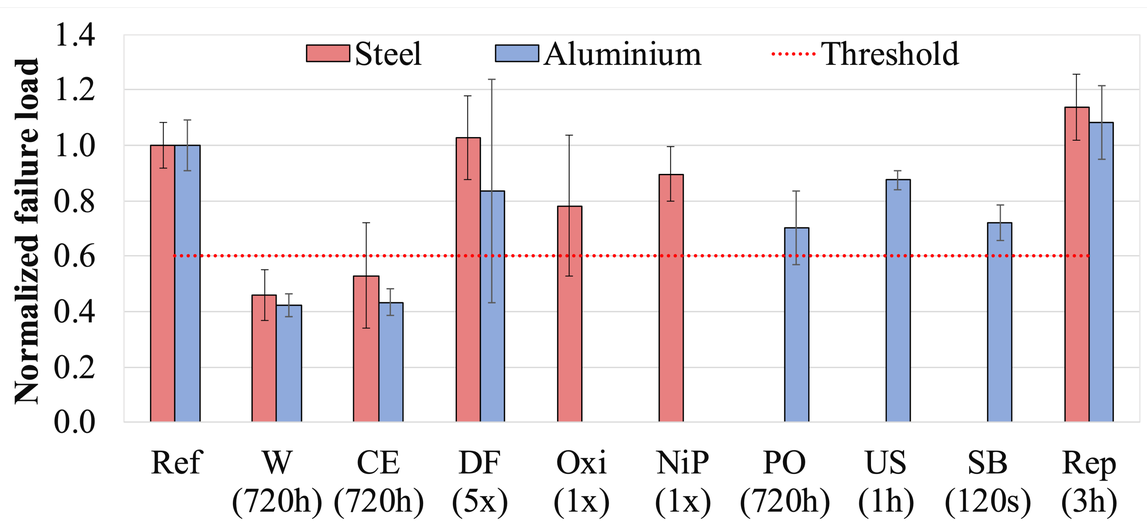


Figure 3 – Normalized shear strength of RJS joints continuously aged [2].

The normalized continuous aging results are presented in Figure 3, for each respective maximum exposure time chosen. The values used depend on the usual exposure time of each fluid.
A limit threshold value of 60% of the reference joint strength was set by the partner company as a safety measure.
The most severe continuous ageing appended for water-based fluids, as their strength went below the threshold value.
As depicted in Figure 4, six petroleum and ultrasound cleaning cycles, as well as 3 repair cycles were also tested.

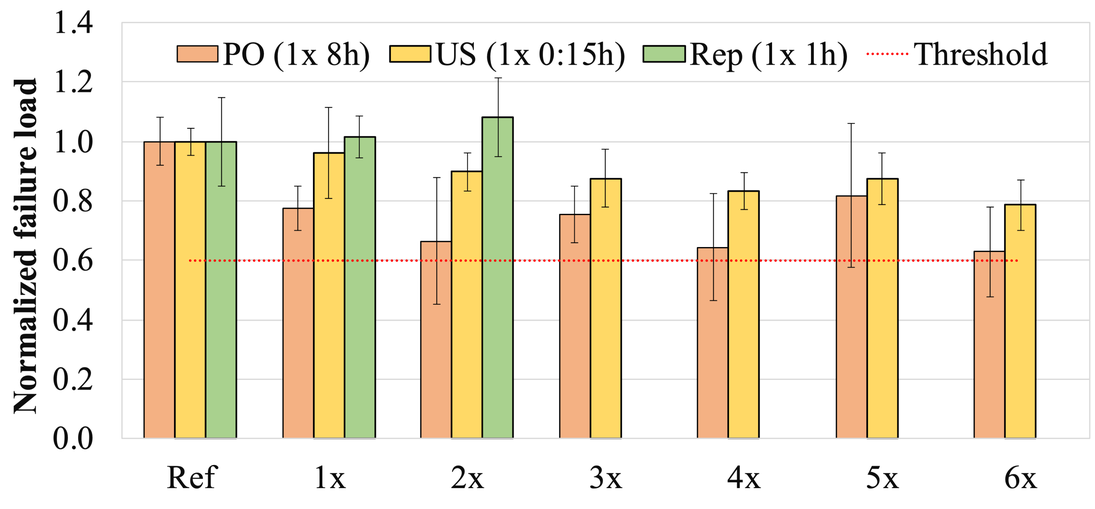


Figure 4 – Normalized shear strength of RJS joints cyclically aged [2].

Results showed that repairing a broken insert does not affect the strength of the undamaged bits due to thermal cycles. From the cyclic cleaning procedures, ultrasounds presented a smaller and more progressive degradation, in comparison to the petroleum fluid which did not present a clear cyclic trend.

## Conclusions

Unlike brazing, adhesives are much more susceptible to long term degradation. The most severe cases were due to water-based fluids (**W**/**CE**) both in adhesive and joint degradation. Nonetheless, although the adhesive might not be affected by other fluids (**DF**,…) in a real joint the interface can be degraded. Tool cleaning is recommended using ultrasounds and repair can be implemented with no real effect on the pristine inserts.

## References

[1] Correia et al., Practical imple. and valid. of a novel process for manufacturing milling tools using adhesive bonding. 2nd International Conference on Advanced Joining Processes: Selected Contributions of AJP 2021, 2021.

[2] de Sousa et al., Analysis of the mechanical perform. and durability of adhesively bonded joints used in the milling industry. Applied Sciences, 2022.