Durability of tube fit joints for busbar–prismatic cell interconnections in electric vehicles

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Introduction

A key challenge is ensuring reliable cell-to-busbar interconnections in EV batteries, as degradation can increase resistance, cause thermal instability, and pose safety risks. Understanding their performance under realistic conditions is therefore essential. This study provides insights into the durability of tube-fit joints for busbar–prismatic cell connections [1] (Fig. 1), focusing on thermal–electrical behavior under cyclic loading.

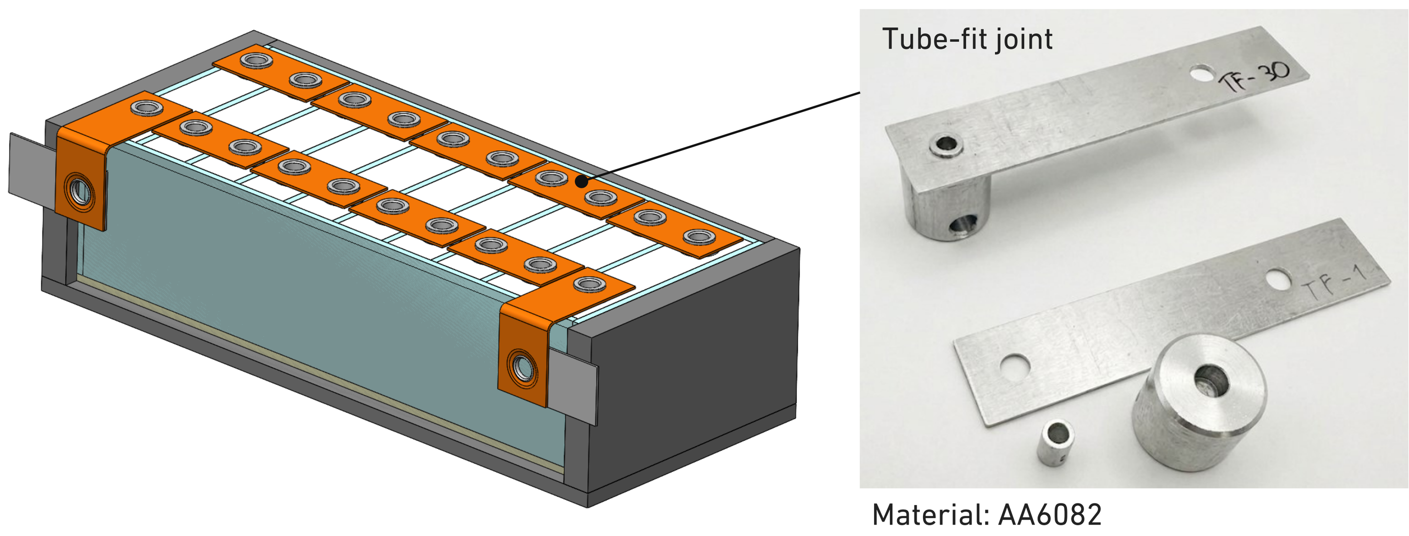

Figure 1– Tube-fit joints for terminal-to-busbar interconnections.

Methods

Load-controlled cyclic shear fatigue tests were performed at 5 Hz with a load ratio of 0.1 and load levels of 500, 750, and 1000 N. Service conditions were approximated as 36,000 cycles (five cycles/day over 20 years), with three inspection intervals to track electrical resistance evolution. A coupled thermal–electrical model was also developed in Abaqus [2] (Fig. 2).

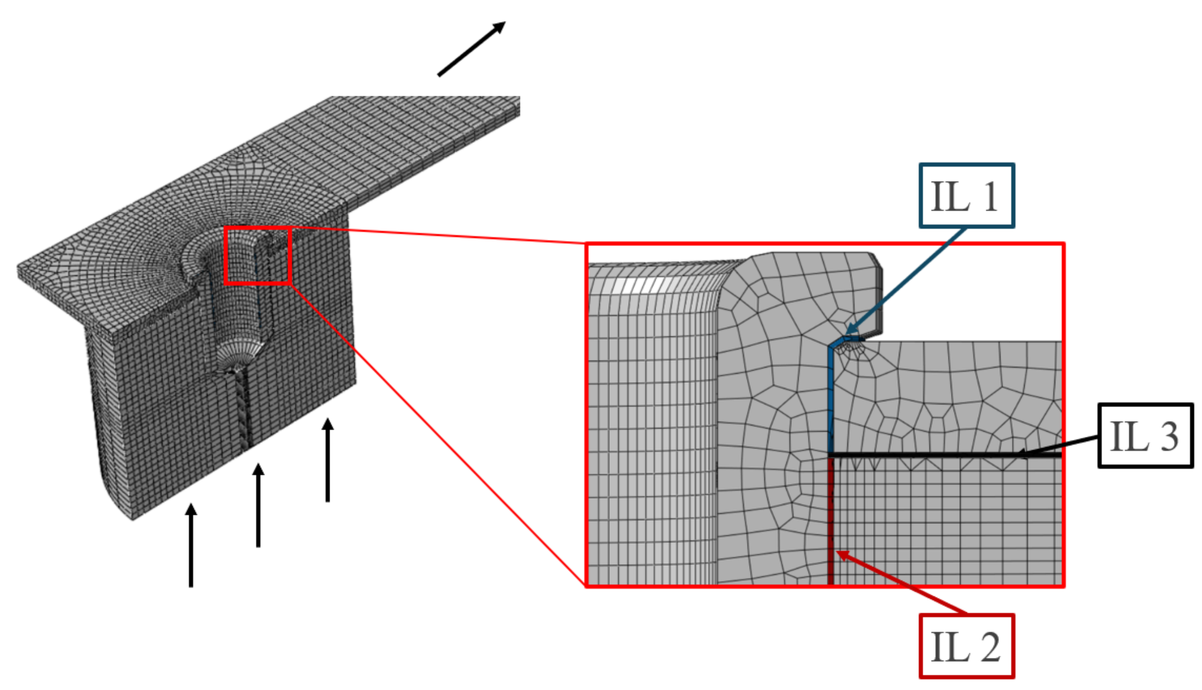

Figure 2– Thermal–electrical model showing mesh details, DC3D8E elements, and interface layers.

Results and Discussion

- Initial cycles show a decrease in electrical resistance due to asperity deformation and increased real contact area (Figs. 3, 4).
- Continued cycling leads to a gradual increase in resistance due to fretting and microslip, reducing effective contact (Figs. 3, 4).
- Higher applied loads improve contact conditions and reduce electrical resistance (Figs. 3, 4).
- The terminal–connector interface dominates the current path, acting as the primary conduction route (Fig. 5).

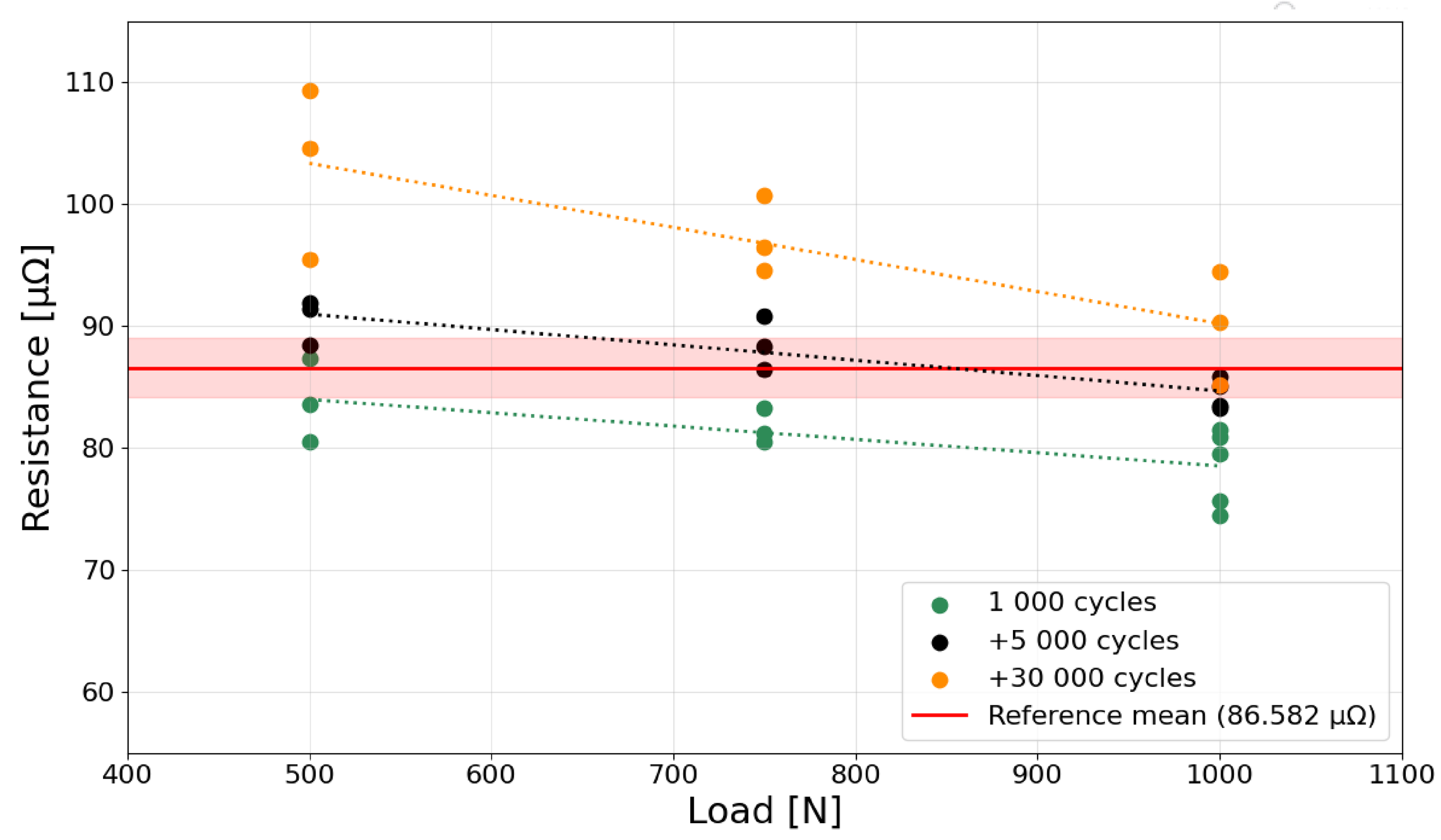

Figure 3– Evolution of electrical resistance under cyclic loading.

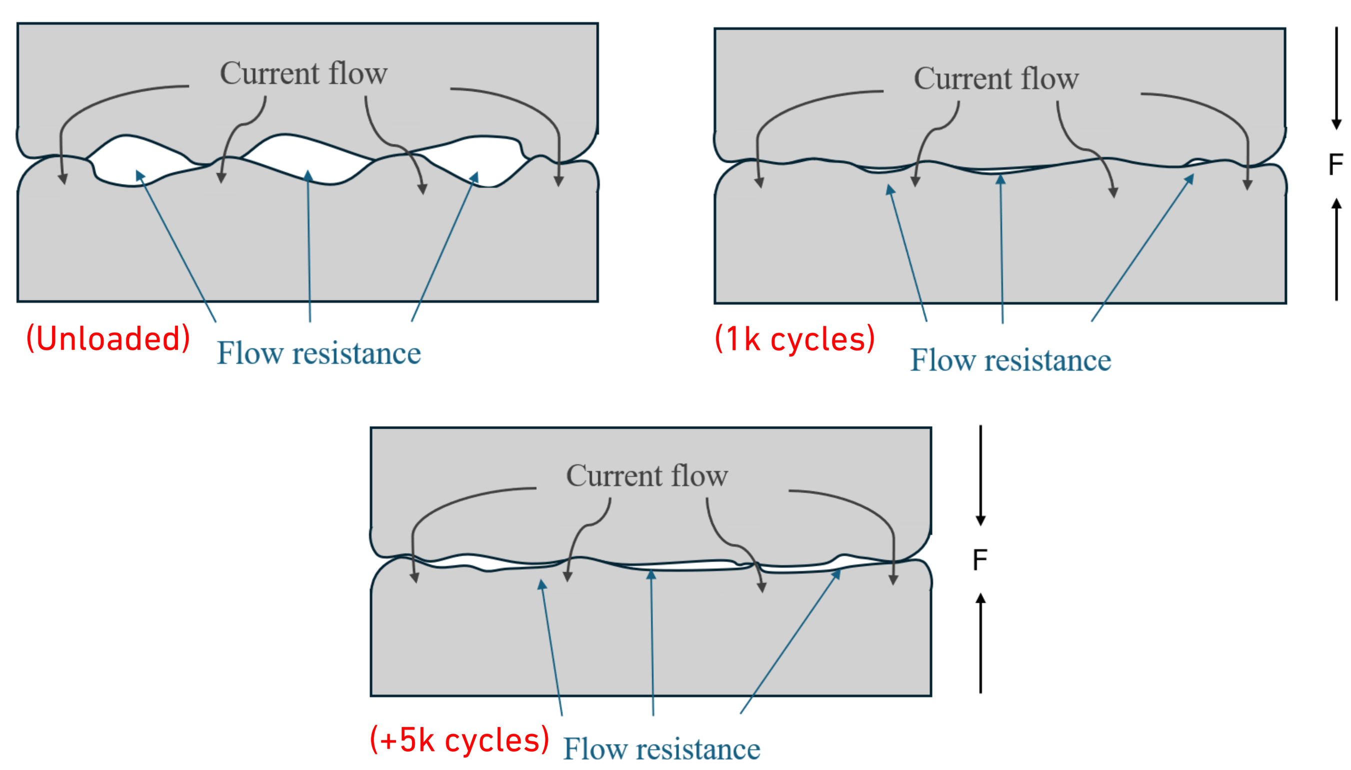

Figure 4– Schematic representation showing the influence of cyclic loading on the effective contact area

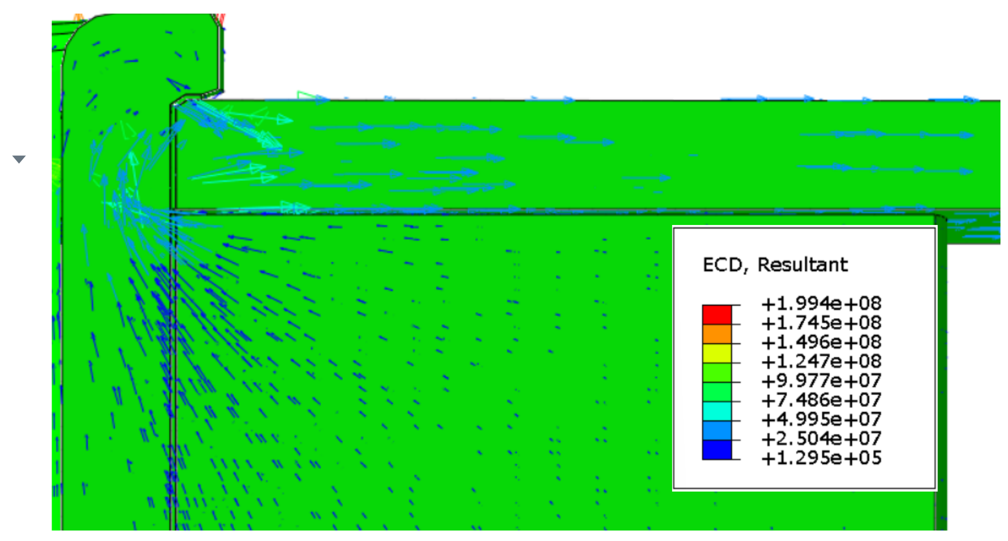

Figure 5– Finite element results illustrating current flow direction using the electrical current density (ECD) vector field.

Conclusion

The results show that electrical performance is governed by contact interface quality rather than nominal area. Resistance initially decreases due to asperity deformation, then increases with fretting and microslip. Higher loads improve contact and reduce resistance. Optimizing connector geometry, especially flange area, is suggested to enhances durability.

References

[1] V.B. Gomes, M.M. Kasaei, R.J.C. Carbas, E.A.S. Marques, L.F.M. da Silva, Int. J. Adv. Manuf. Technol. 137, 2405 (2025).
[2] V.B. Gomes, M.M. Kasaei, R.J.C. Carbas, E.A.S. Marques, L.F.M. da Silva, Mech. Adv. Mater. Struct. 1, 1 (2025).

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