Accumulator Design for an FSAE Electric Racecar

In Partnership With UVic Formula Electric

PURPOSE

Since 2012, the UVic Motorsports team has designed high-performance, open-wheeled, formula-style racecars powered by combustion engines. This year, however, UVic Motorsports' formula electric subsidiary (UVFE) is designing their inaugural electric-motor driven racecar. The goal of this project is to design the accumulator for this electric vehicle. This project was selected because Group 18's team members are passionate about battery technology and the positive impacts that innovative batteries might have on the environment. For example, as battery technology improves, electric vehicles will acquire better range, efficiency, and charging time, encouraging their use and ultimately reducing fossil fuel emissions [2]. In addition, renewable energy sources like wind and solar could become more practical with the availability of innovative energy storage [3]. Working on this project allowed group 18 to develop a strong understanding of battery design and technology, which can now be applied to other exciting and meaningful applications.

PROJECT SCOPE:

The scope of this project can be divided into the design of several crucial accumulator systems and the specification of several pieces of supporting hardware:

DESIGN OBJECTIVES:

- Cell configuration and layout.
- Main current path busbars and per-cell fusing.
- Accumulator container.

SPECIFICATION OBJECTIVES:

- Accumulator isolation relays (AIRs)
- Maintenance plugs
- Battery management system (BMS)
- Main overcurrent protection device

ANALYSIS / DESIGN

LITERATURE REVIEW:

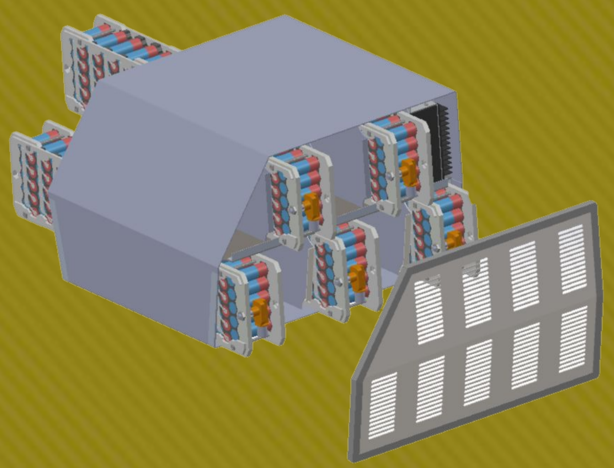
- Selection of the supporting hardware for the accumulator was informed by a survey of former student projects.
- Electrical specifications, cell configuration, and welding techniques were influenced by previous FSAE entries.

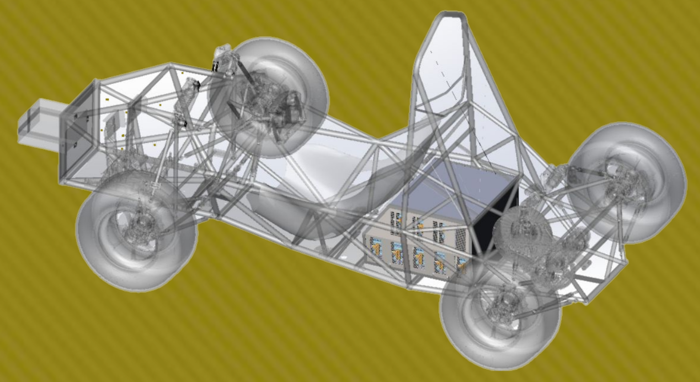
RESEARCH AND EXPERIMENTATION:

- Electrical characteristics of the accumulator were determined through careful consideration of FSAE regulations [1] and a desire to maximize accumulator voltage.
- Cell selection and orientation were informed by a comparison of available lithium-ion cells, with a particular focus on cell capacity, maximum current discharge, and weight.
- The partitioning, arrangement, and supporting hardware inside the accumulator container were informed by FSAE regulations [1] and a need to fit the space restriction of the current chassis design.
- Busbar material and dimensions were informed by research, and direct experimentation.
- Overcurrent protection was designed at both the per-cell level and main current path level through research, comparison of available off-the-shelf devices, and direct experimentation.
- Heat calculations and careful consideration of FSAE guidelines [1] allowed for an accumulator container design providing adequate accumulator cooling and structural integrity.

SUMMARY OF FINAL DESIGN

- Total of 680 Samsung 40T 21700 lithium-ion cells [4].
- Eight accumulator segments, each containing 85 cells in a 17s5p configuration for a total accumulator configuration of 136s5p.
- Maximum accumulator voltage: 571.2VDC.
- Maximum accumulator current: 196.1A.
- Maximum rated power output of 80kW or 107HP at all charge levels.
- Total stored energy: 9.792kWh.
- Overcurrent protection through the use of waterjet-cut per-cell fuses rated at 90A and a Littlefuse IDSR150 slow-blow main accumulator fuse rated at 150A [5].
- Total volume: 430.0 x 291.5 x 468.0mm = 0.0587m^3





CONCLUSIONS

This design conforms to the FSAE guidelines [1] while maximizing vehicle performance. Achieving this goal required diligent research and meticulous experimentation. The project scope was fully covered with the exception of a finite element analysis of the accumulator container. Recommended future work includes: completing a finite element analysis for the accumulator container, sizing and routing power and sensor cables, and mounting of the supporting hardware in the reserved triangular accumulator cavity. Upon completion of this recommended work, the accumulator will be ready for fabrication, testing, and design validation.

REFERENCES

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Group 18: Tenzin Blair - V00802873
Kurtis Archibald - V00951059
Charlie Plaskasovitis - V00865145