Ecole Centrale de Lyon – Car n°281

C - Powertrain concept & choice, simulation, design, & analysis

Battery pack

Objectives

- Allow safe use and safe handling of the components
- Finish the Endurance Event

Design and manufacturing strategy

- Buy an existing battery pack
- Supplier: **Electric Power** Hong-Kong.

Cell specifications

Name	Value
Supplier	Electric Power, Hong Kong
Nominal Capacity	8300 mAh
Nominal / max Voltage	3.7 V / 4.2 V
Max constant/peak discharge current of 1 cell	125 A (15 C) / 250 A (30 C)

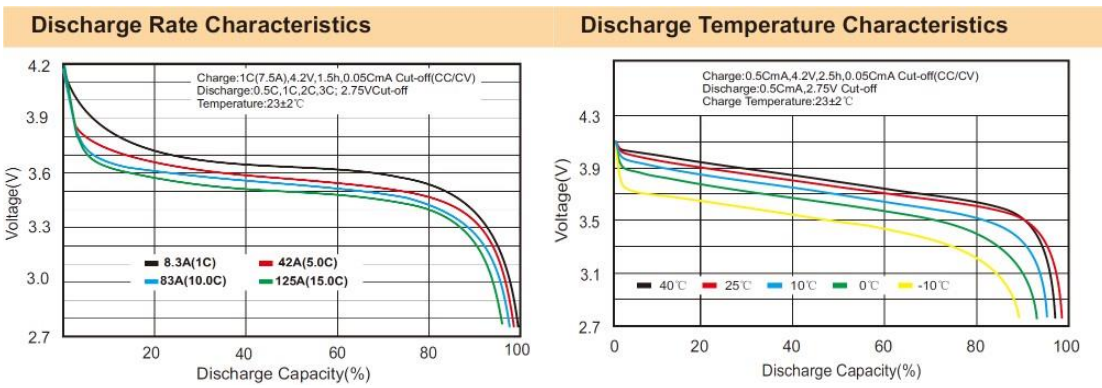


Fig 1. *Cell characteristics for discharge rate and temperature.*

Energy required

The amount of energy required for the endurance event can be limited by restricting the power delivered by the battery pack (*Fig 2).* Thus it is possible to **save volume** and to make the **integration in the car** easier.

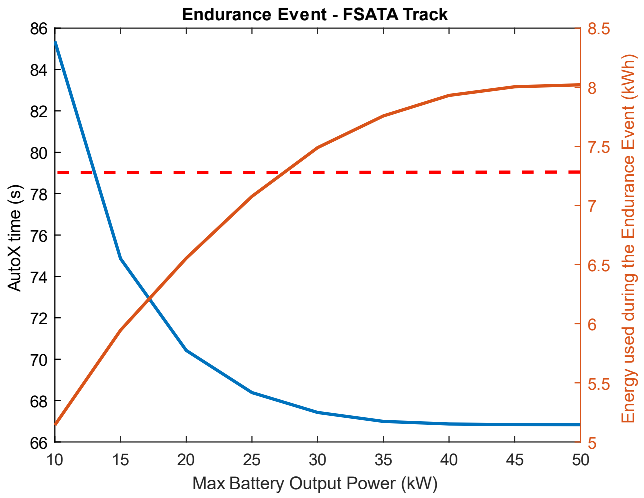


Fig 2. *Energy required after lap time simulations*

Battery pack specifications

Name	Value
Cell Configuration	120S2P
Nominal capacity	16.6 Ah ⇔ 7.37 kWh
Nominal Voltage	444 VDC
80 kW discharge current per cell	90 A (11 C) **(safety factor of 1.3)**
50 kW discharge current per cell	56 A (7 C) **(safety factor of 2.1)**

Engine and drivetrain integration

Objectives

- Complete the **acceleration** event in **4.4 sec**
- **Finish** the **endurance** event

Engine choice

Component	Choice
Engine	1 rear engine, EMRAX 228 Medium Voltage, Liquid Cool
Engine Inverter	BAMOCAR D3
Engine max continuous power	53 kW
Engine Voltage	500 VDC

Drivetrain design

The minimum drive ratio that allows us to achieve our time objective is **3.23**. However, this ratio consumes too much energy to complete the endurance event. Therefore, we decided to keep this ratio and **limit the output power of the battery** during the endurance in order to not exceed 7.3kWh (see *Fig 4).*

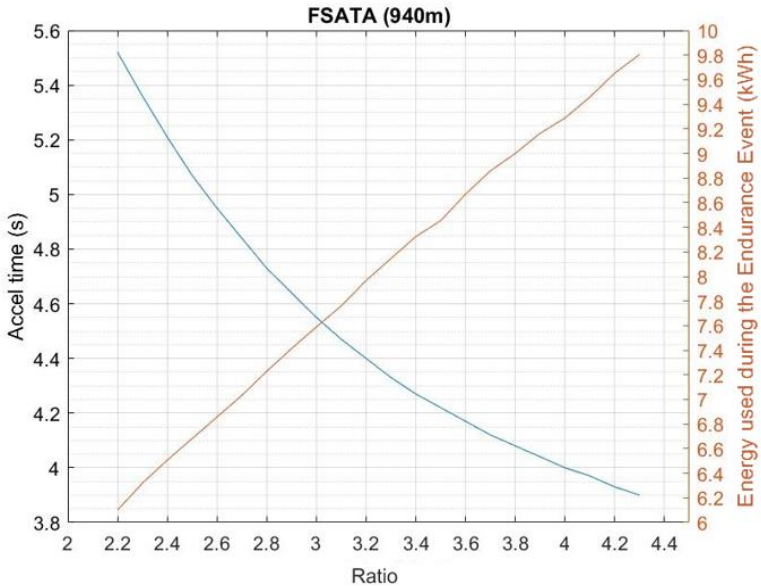
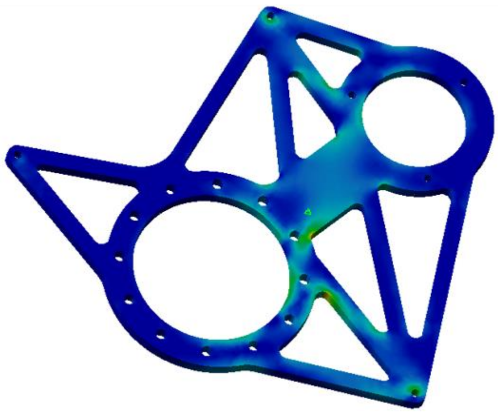


Fig 3. *Acceleration event time and energy used during the endurance event for different drive ratios*

Simulations



Boundary conditions

- Bearing type on the 2 bearing seats
- Embedment around screw positions

Results:

- Ks=2 with FEA for Re=200 MPa

Fig 4. *Simulation on the motor and differential mount*

Cooling system

Objectives

- **Dispel the thermal power** of the engine and inverter: 6 kW

Architecture choice

Single-loop or dual-loop circuit: As the operating temperature of both the engine and the inverter matches, we chose the single loop option for costs and space reasons.

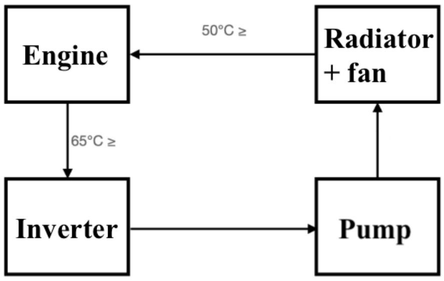


Fig 5. *One loop architecture for the cooling system*

Air flow specifications

A thermal model was programmed on matlab using the ε-NTU method (empirical method) to test different dimensions giving such results (*Fig 6)*:

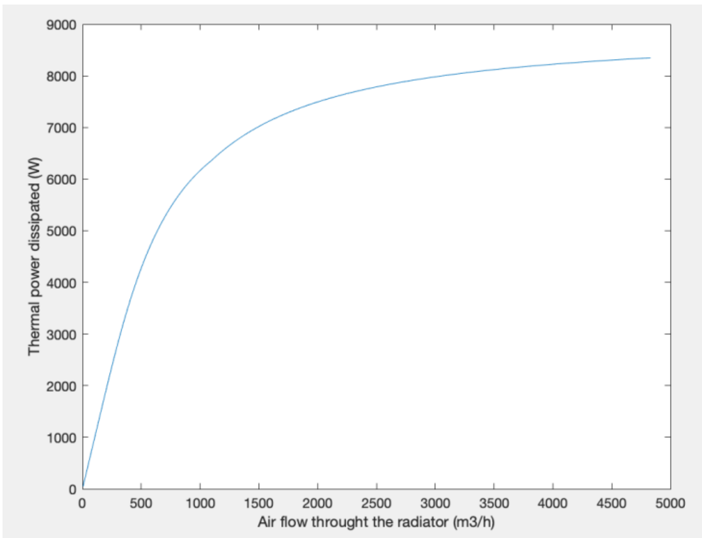


Fig 6. *Thermal power dissipation through the radiator*

Testing plan on our powertrain test bench

Objectives of the bench

- Help to design a **safe** and **reliable** first vehicle by validating the tractive system elements
- Monitor the aging of our battery during simulations of typical vehicle's runs.

Testing strategy

1 - For the battery pack

- **External validation** of the whole **battery pack**
- The battery will be manipulated by the students only after this validation process

2 - For the powertrain

- Tests of **acceleration**: acceleration of the motor at the maximum instruction of torque.
- Tests of **endurance**: work of the motor during a long time (more than 10 minutes) at a fixed speed and torque.
- **Versatile** tests: tests of 5 minutes with accelerations and decelerations at different torques. These tests will simulate different runs of the vehicle.

Test bench architecture

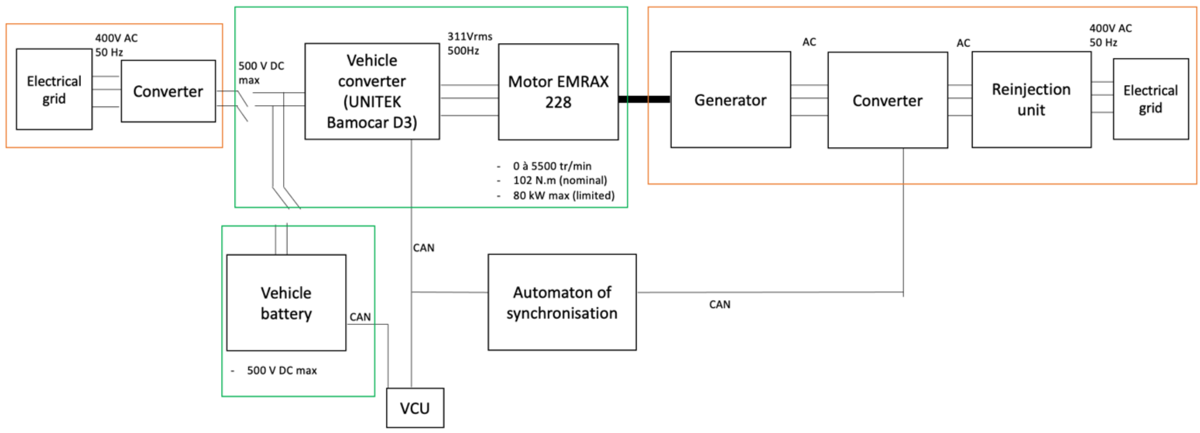


***Fig 7.** Wiring diagram of Bench01, our powertrain bench.*
In orange, specific components of Bench01 and in green the tractive system of our vehicle.

Security considerations

In order to protect the materials and manipulators, we decided:

- To **protect every moving part** of the bench 01. It includes the motor of the vehicle (Emrax 228), the generator (Siemens 1PH8) and coupling of the two.
- To buy **individual protections** for each manipulator
- To have a **professional installer** do the installation of the bench and do the first start.
- To impose the writing of a **specific procedure** about the action to do during tests.