

Battery Pack Temperature Distribution Simulation with COMSOL and MATLAB®

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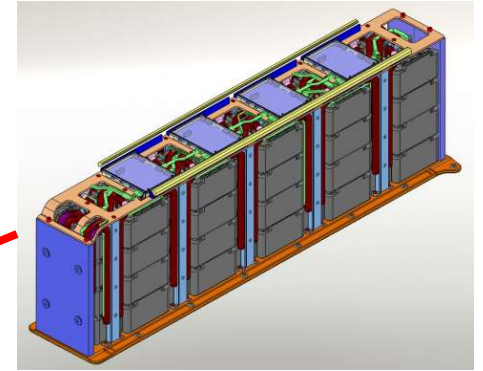
Why COMSOL and MATLAB®

	COMSOL	MATLAB
3D CAD import	○	
FEM and CFD	○	
Monitoring	○	○
Large System Integration		○

Objective of this Work

Combination between COMSOL and MATLAB® for a liquid cooling system of a battery pack

Electric Car



Electric Car

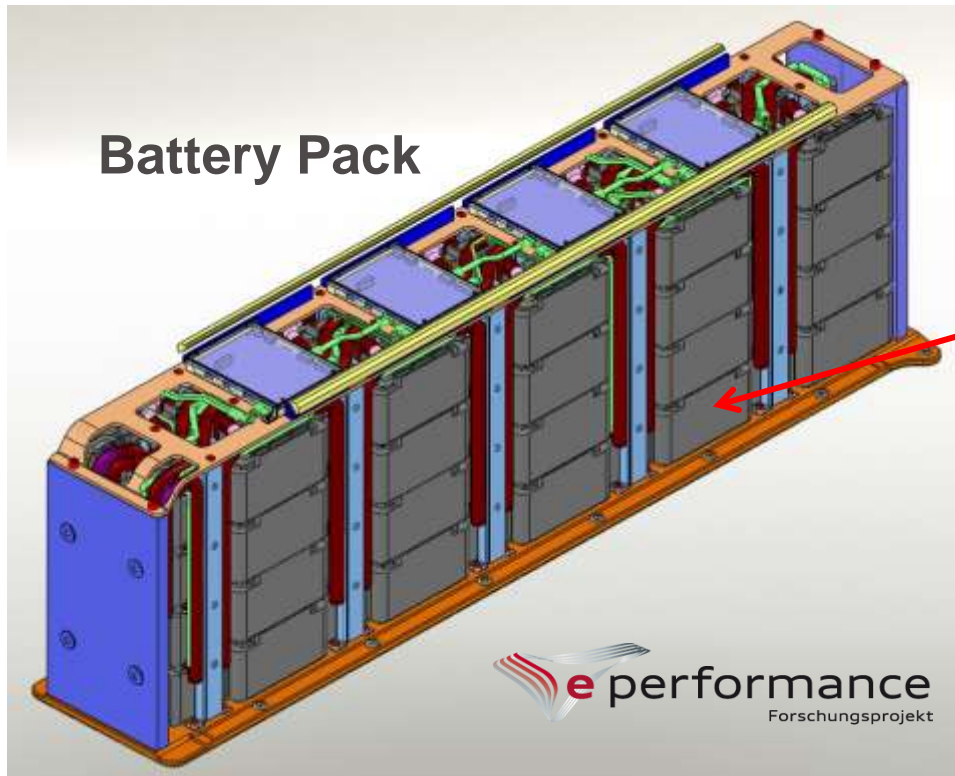


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Battery Pack



80 Battery Modules

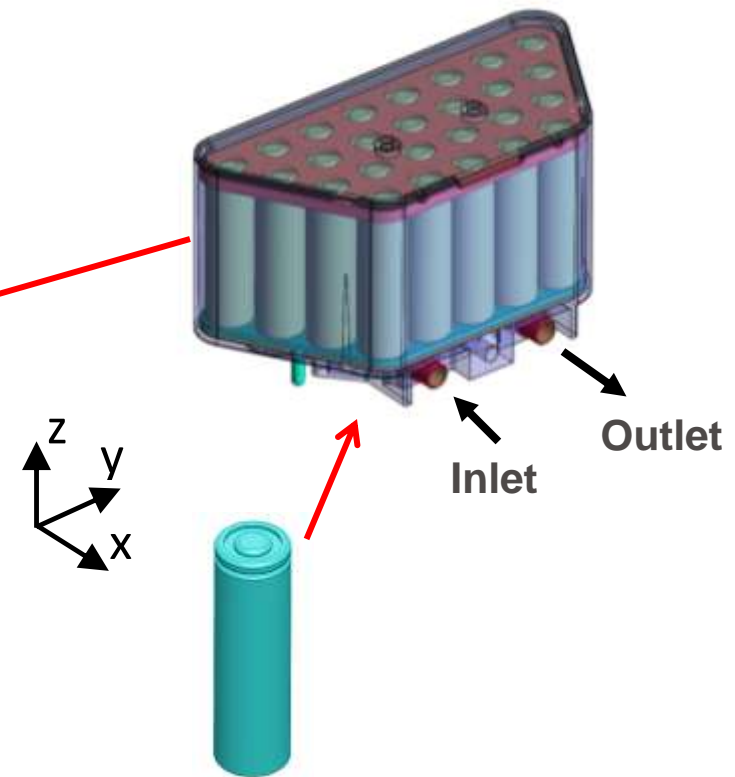
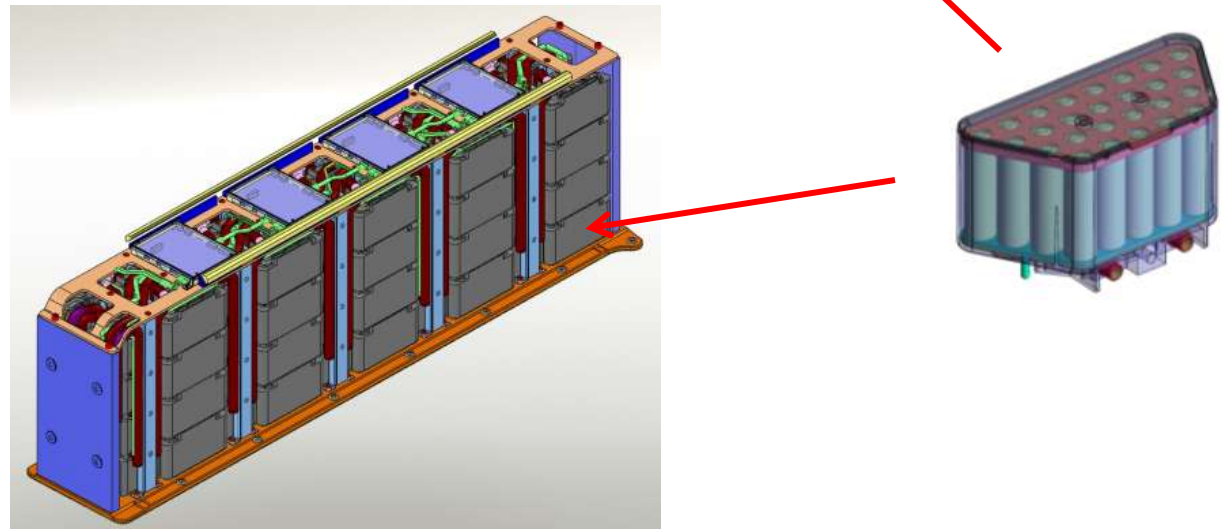
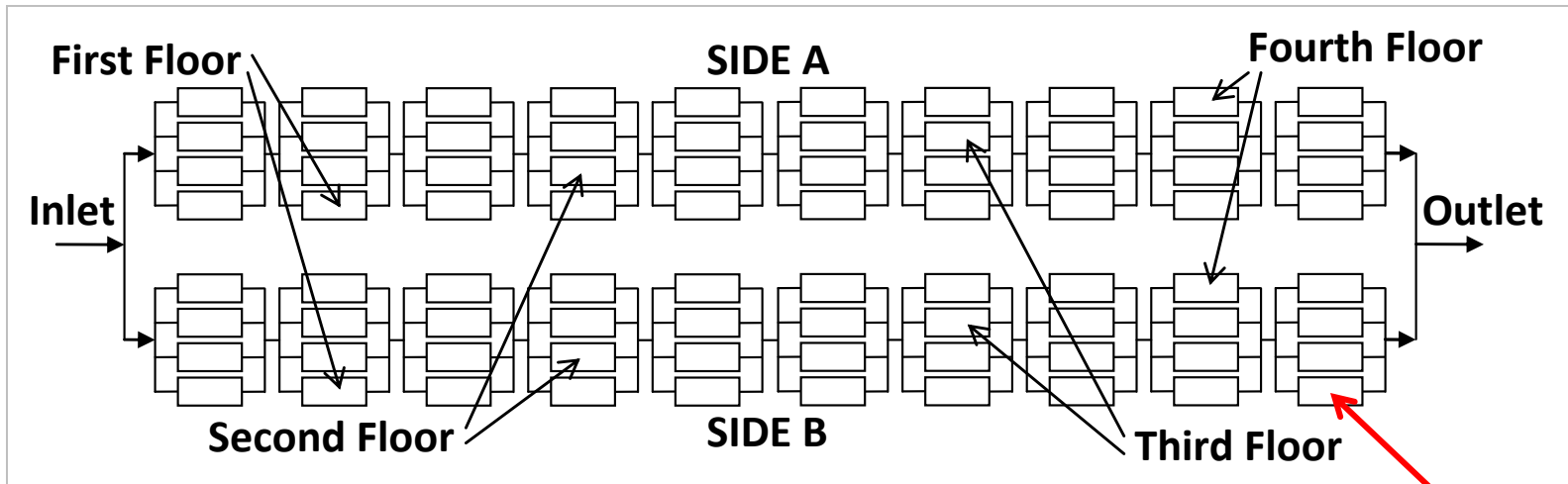
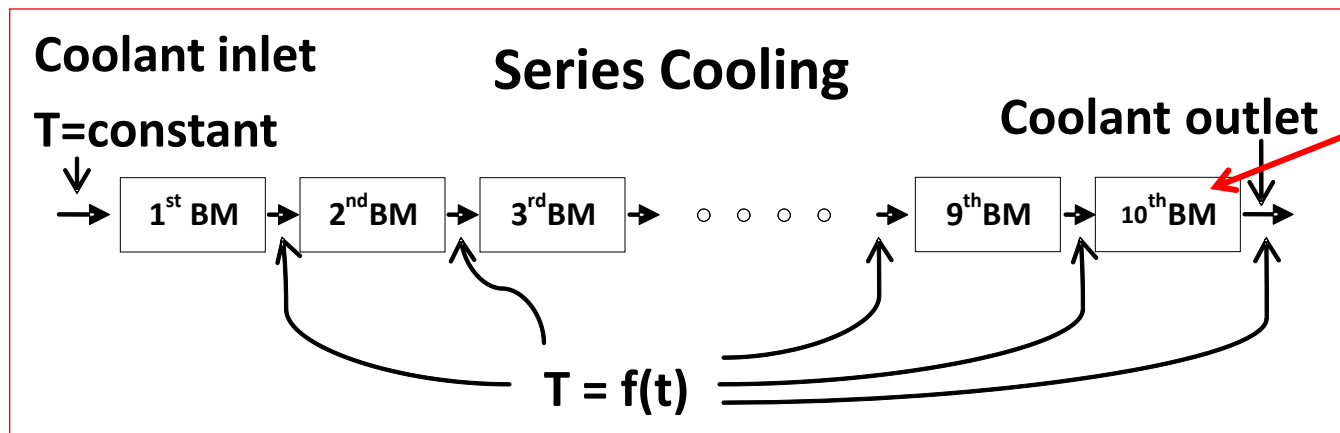
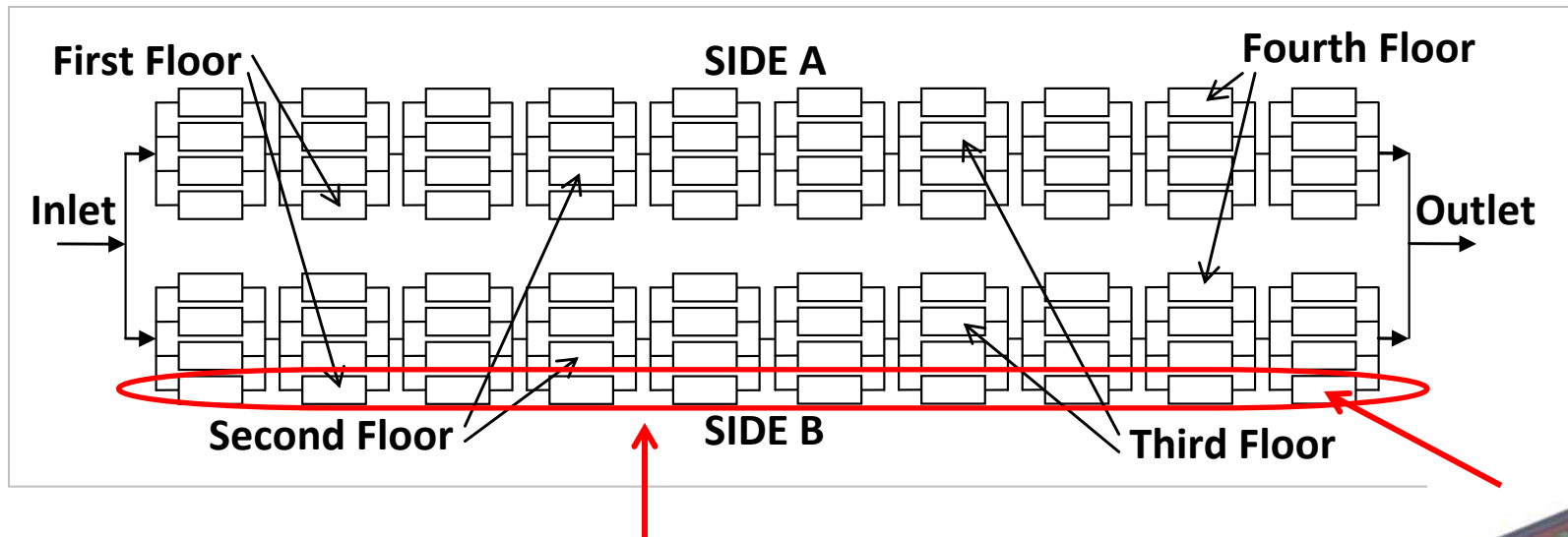


Diagram of the Cooling System

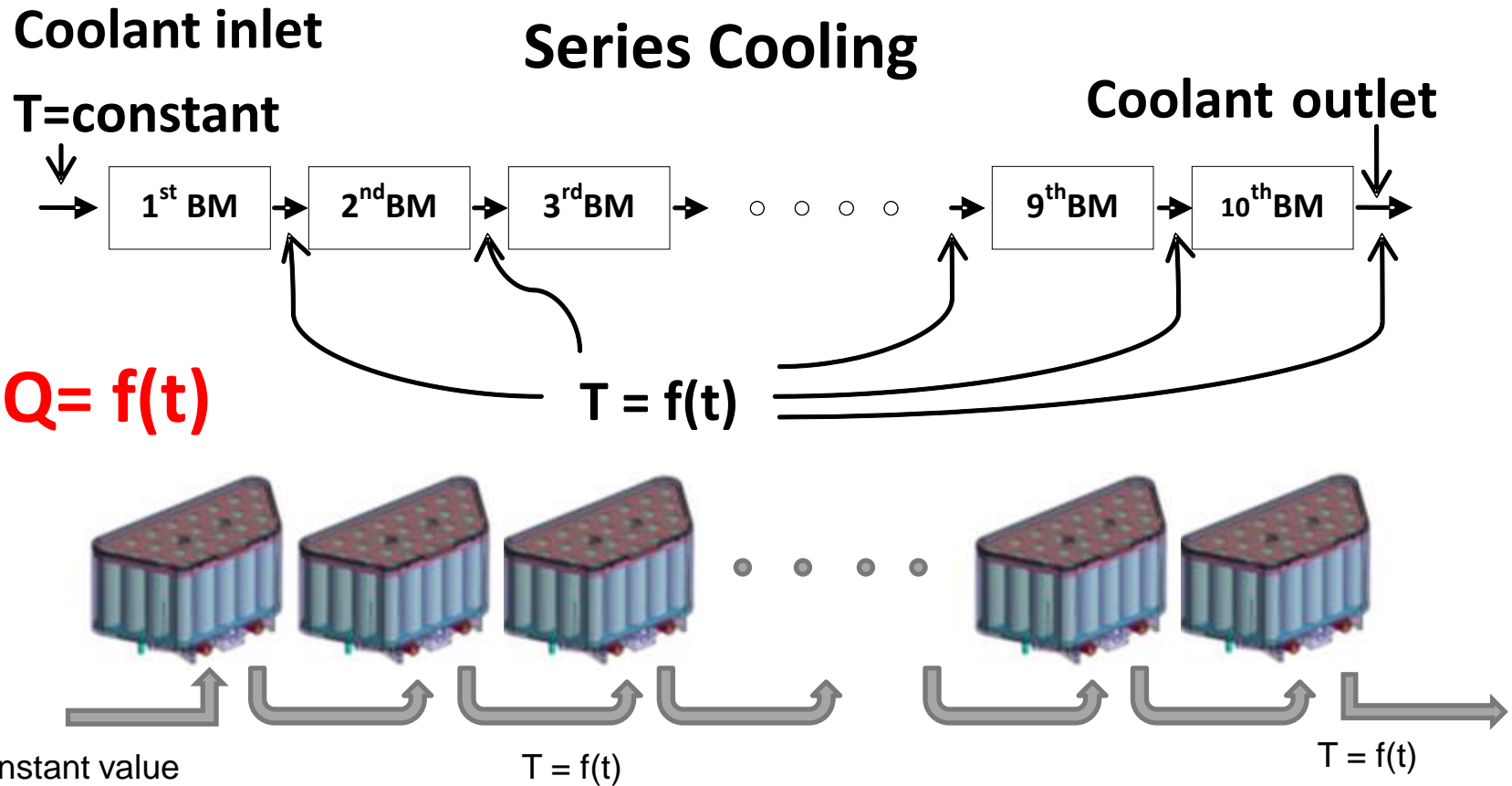


Simplifying the Cooling System



Flow rate in each channel, 12.5 %

Simulation problem

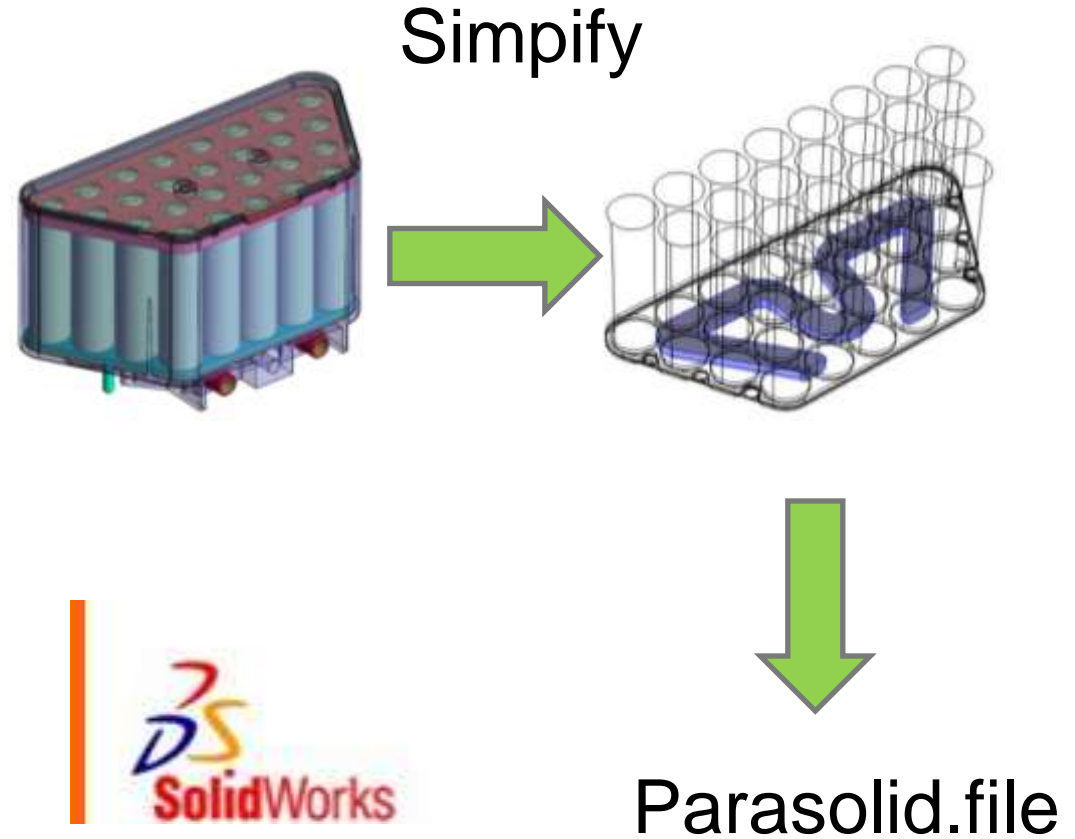
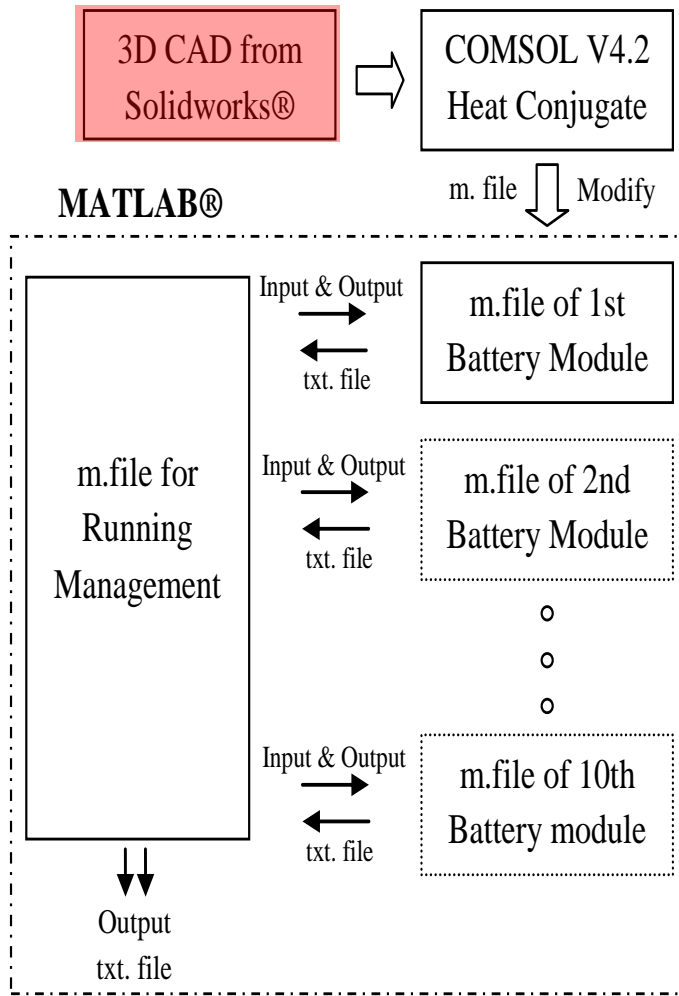


Heat generation in each battery module depends on electric load.

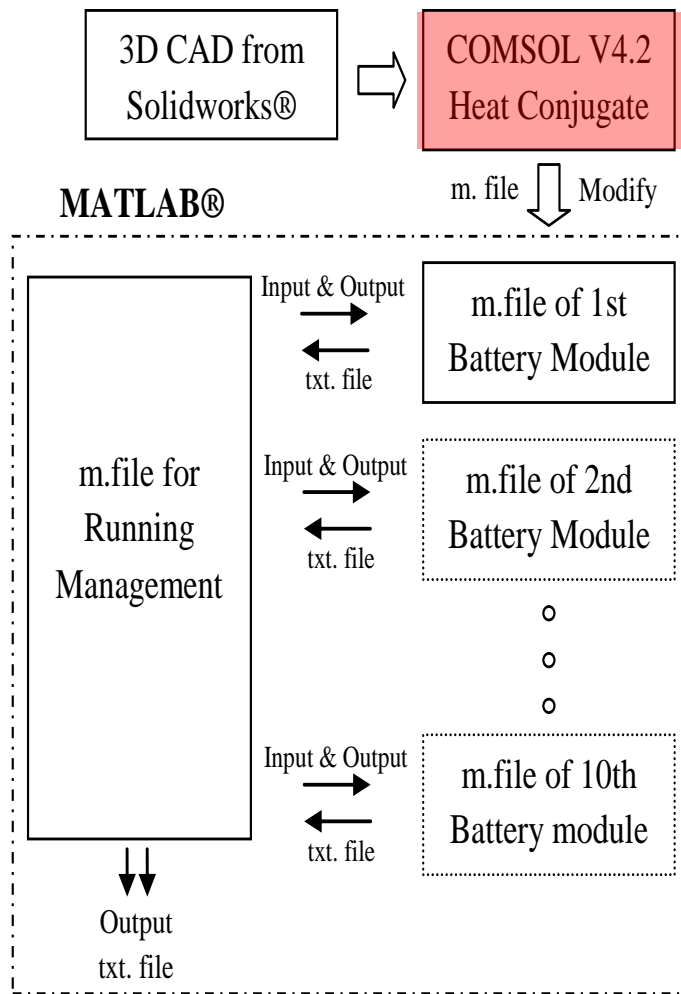
Techniques for Simulation

	10 Battery Modules in COMSOL Only	One Battery Module at a time	
		COMSOL Only	COMSOL with MATLAB
Time of mesh Generation	-	Medium	Medium
Data Management	Not Required	Medium	Automatic
Computer Performance	High	Medium	Low
Total runtime	-	Normal	Faster

Soldworks ® – 3D CAD Making



COMSOL – Setting



Setting

- Material Property
- Boundary Condition
- Mesh Generation
- Heat Conjugate Module
- Laminar Flow
- Transient Study

Parasolid.file ↓



COMSOL



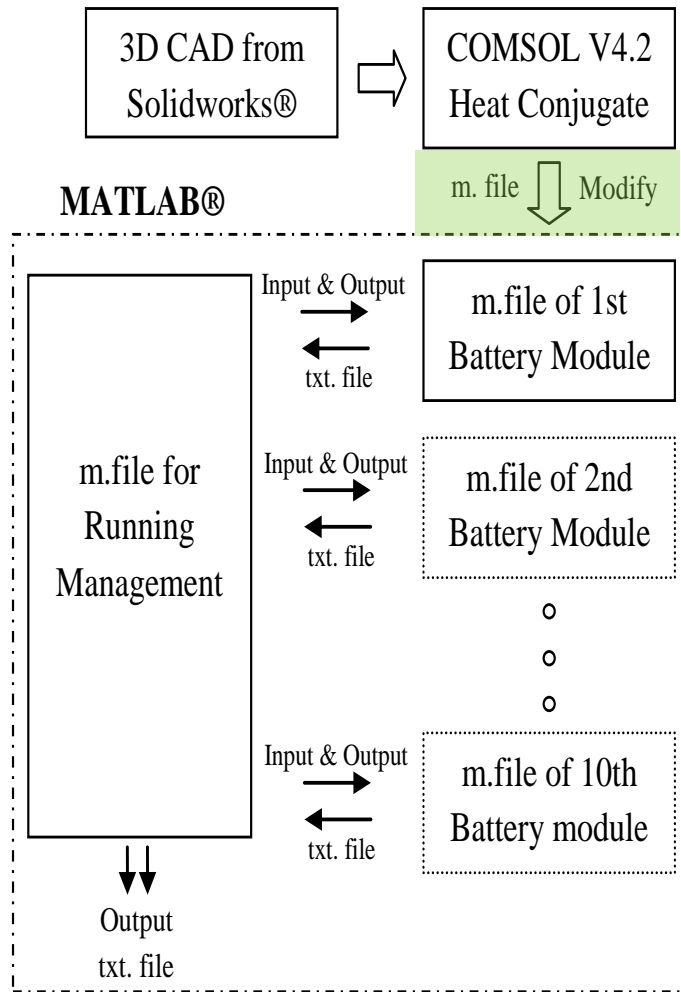
Running



m.file

To test model in COMSOL

MATLAB® – m. file of Battery Module modify



Manual Modification

- So that the m. file from COMSOL can exchange parameters between m.files.
 - Normal Values
 - Values in form of txt.file, in case the values as a function of time

m.file from COMSOL

Modify

MATLAB ® – m. file of Battery Module modify

How to import *txt.file*?

```

model.func.create('int1', 'Interpolation');
model.func('int1').model('mod1');
model.func('int1').set('source', 'file');
model.func('int1').set('filename', 'D:\running model\Version1\Heat_Loss.txt');
model.func('int1').setIndex('funcs', 'Heat', 0, 0);
model.func('int1').importData;
    
```

Heat_Loss.txt

0	80
0.1	80
⋮	⋮
⋮	⋮
1200	2.5

Time (s) →
← Heat Generation(w)

How to use *txt.file*?

```

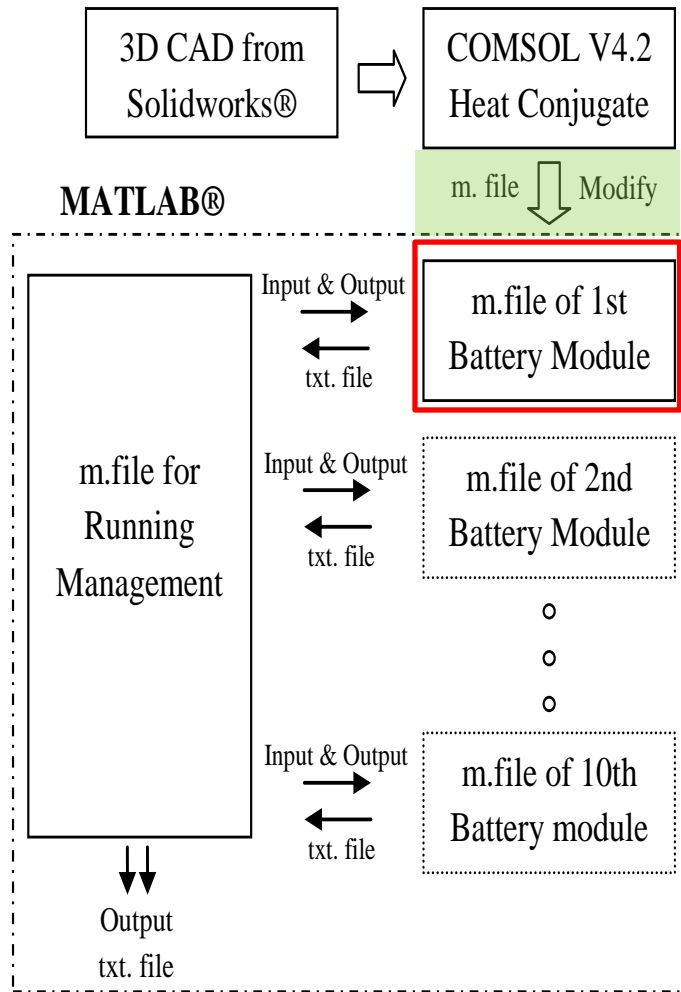
model.physics('nitf').feature('hs1').set('Ptot', 1, 'Heat(t)');
    
```

How to use *normal parameter (Constant Value)*?

```

model.physics('nitf').feature('in11').set('U0in', 1, 'Flow/Area');
    
```

MATLAB® – m. file of Battery Module modify



Manual Modification

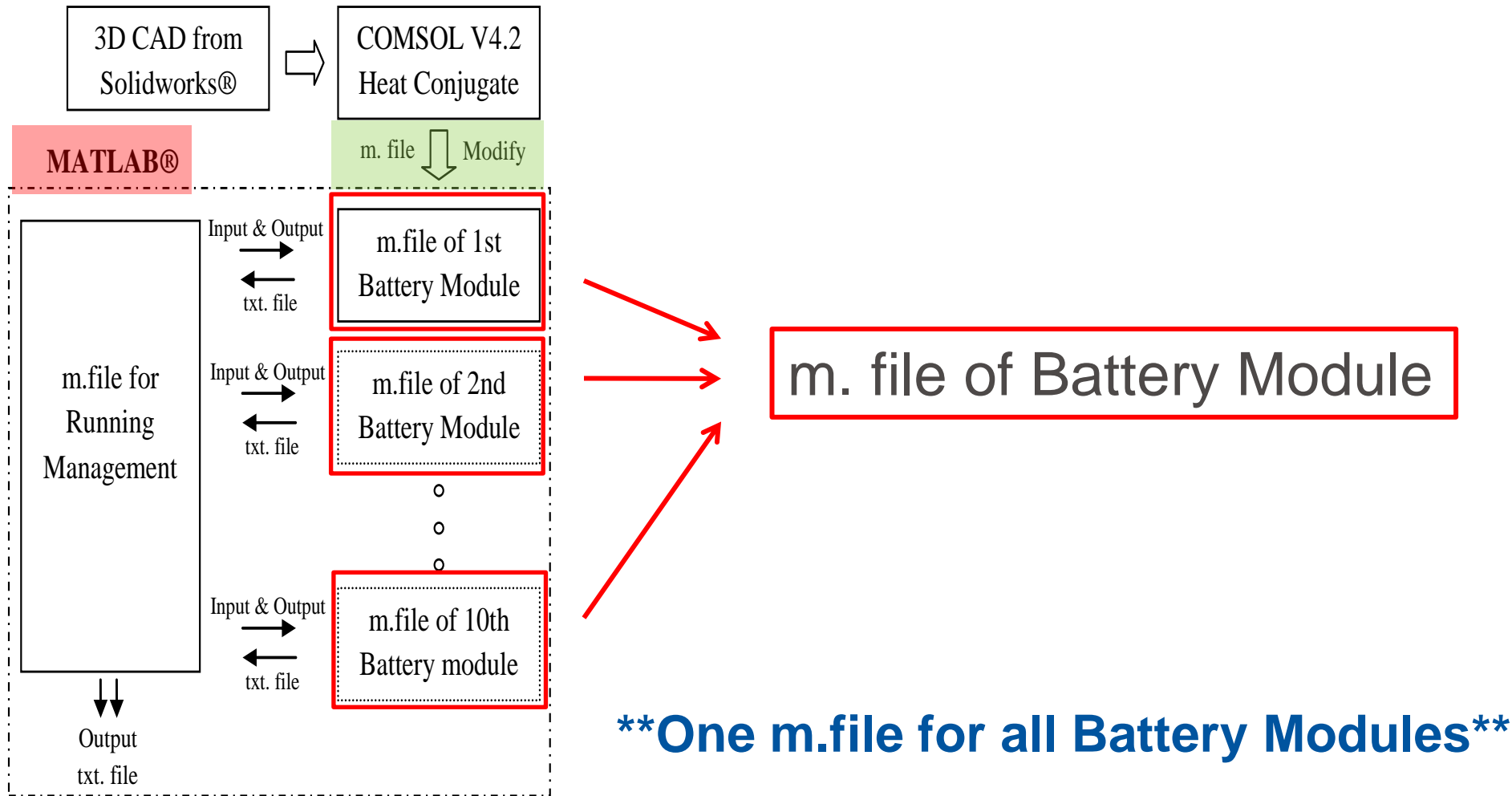
- So that the m. file from COMSOL can exchange parameters between m.files.
 - Normal Values
 - Values in form of txt.file, in case the values as a function of time

m.file from COMSOL

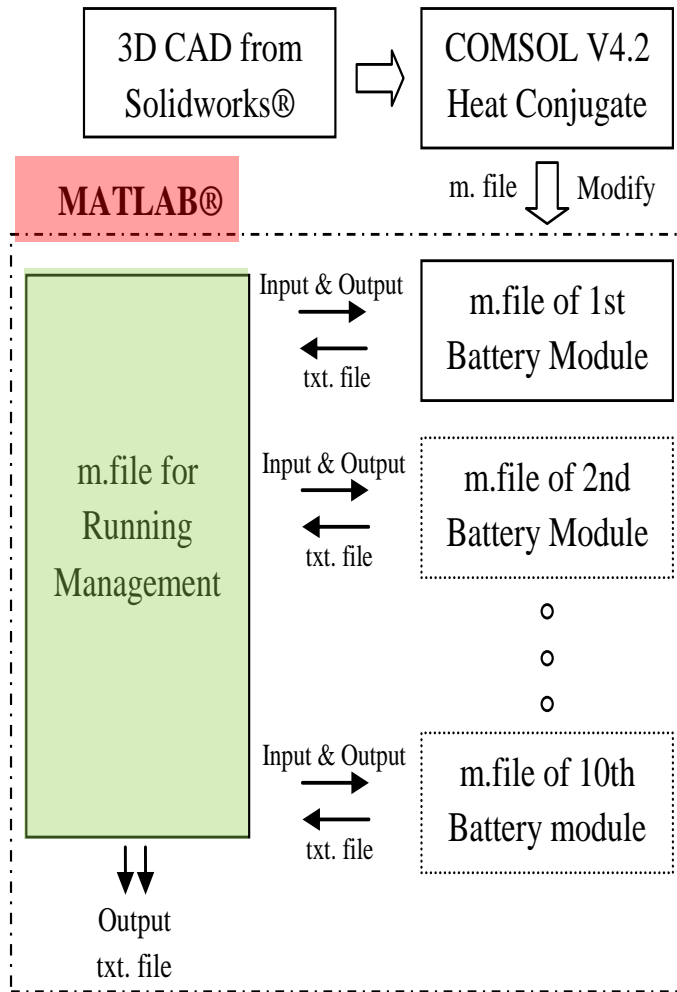
Modify

m. file of Battery Module

MATLAB® – m. file of Battery Module modify



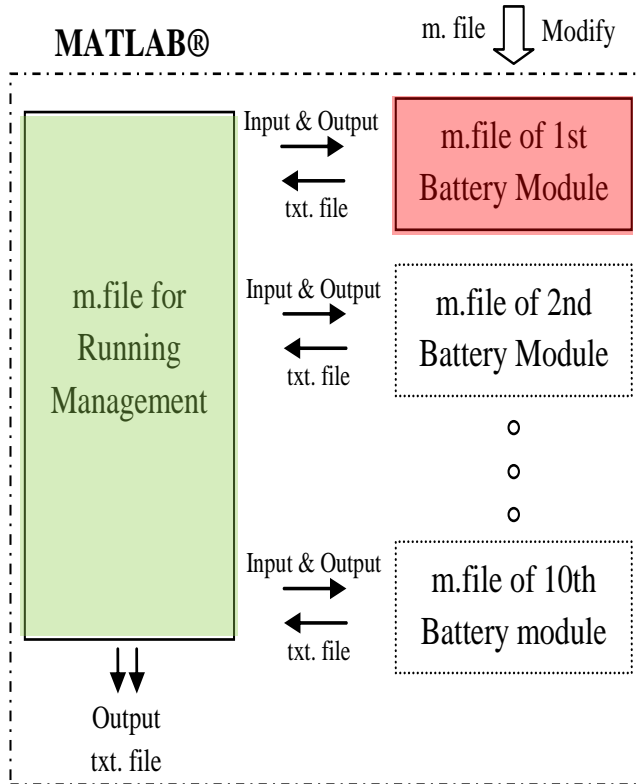
MATLAB® – m. file for running management



Functions

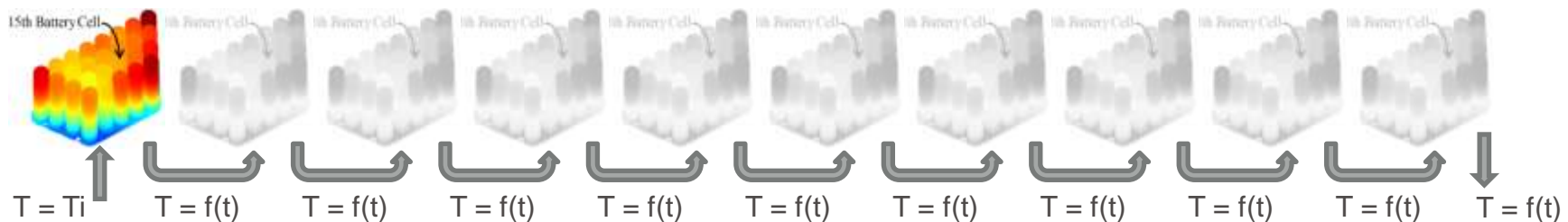
- **Start running** each *m.file of Battery Module in serial*
- **Set parameters** both txt.file and normal values
- **Collect and save the results** to txt.file
- **Calibrate the results** of previous battery module before setting the inputs of next battery module
- **Show runtime** of each *m.file of Battery Module*

MATLAB® – Running Process BM-1

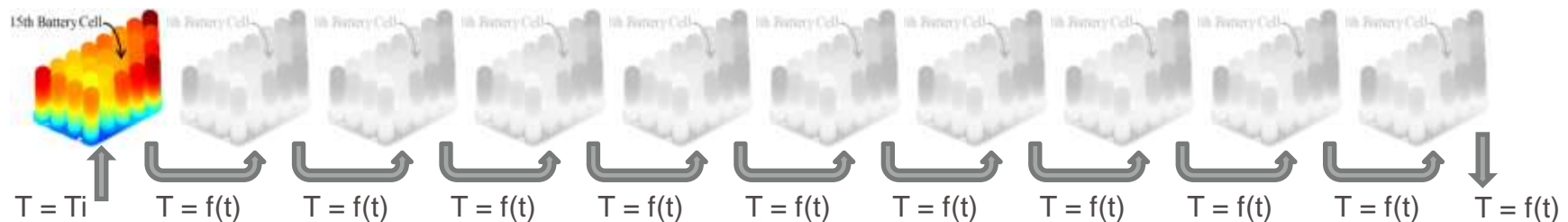
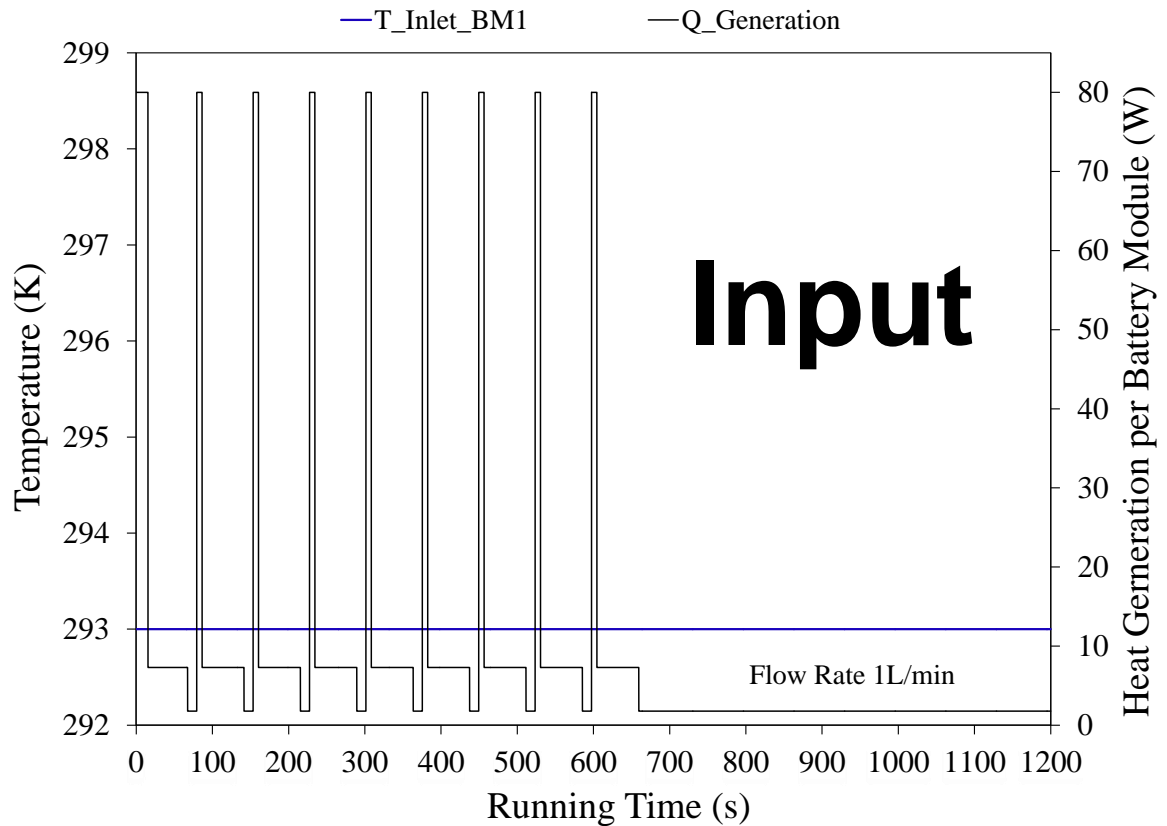
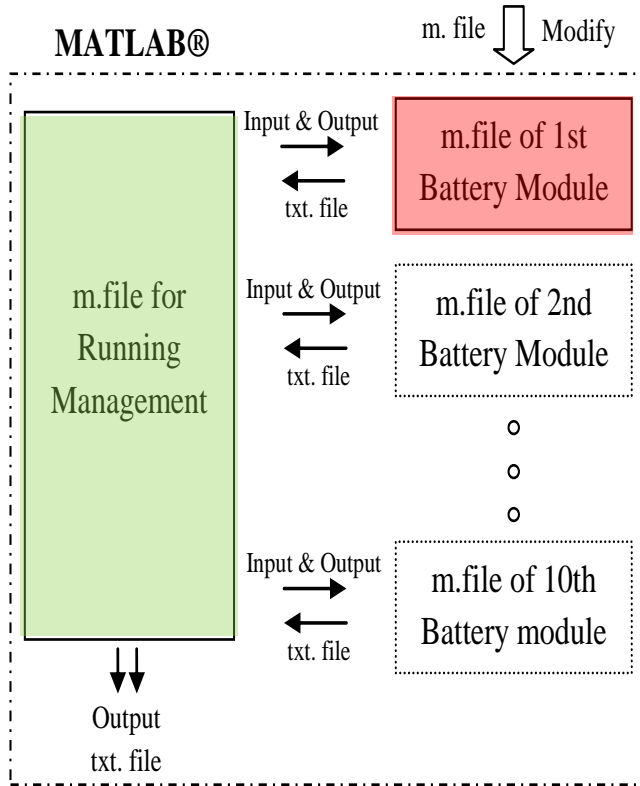


Input of First battery module

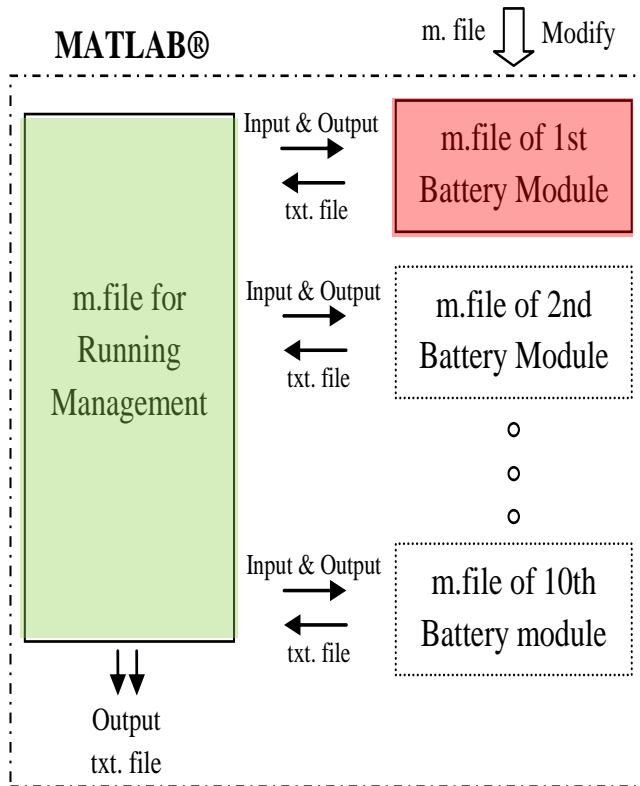
- Inlet temperature is **constant**, 298 K.
- Flow rate of coolant is 1 L/min
- Heat generation as function of time(txt.file).



MATLAB® – Running Process BM-1



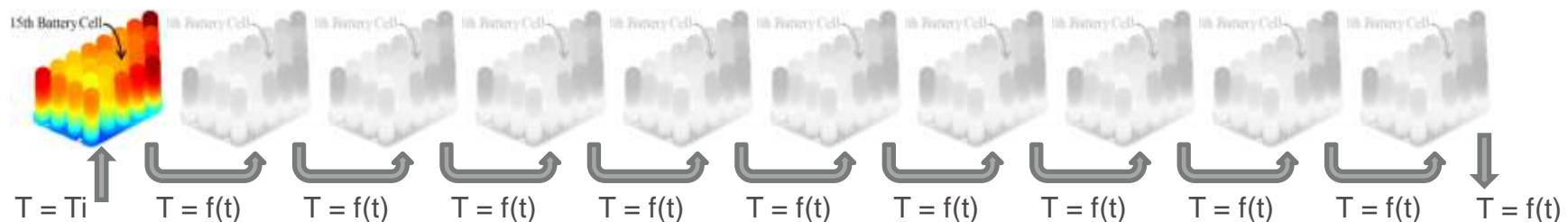
MATLAB® – Running Process BM-1



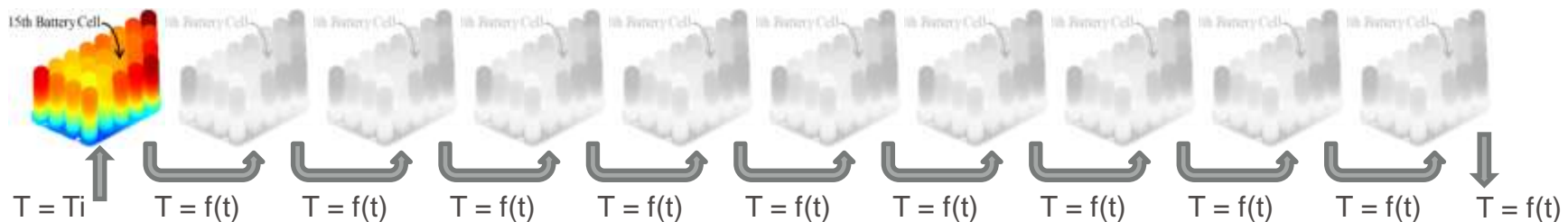
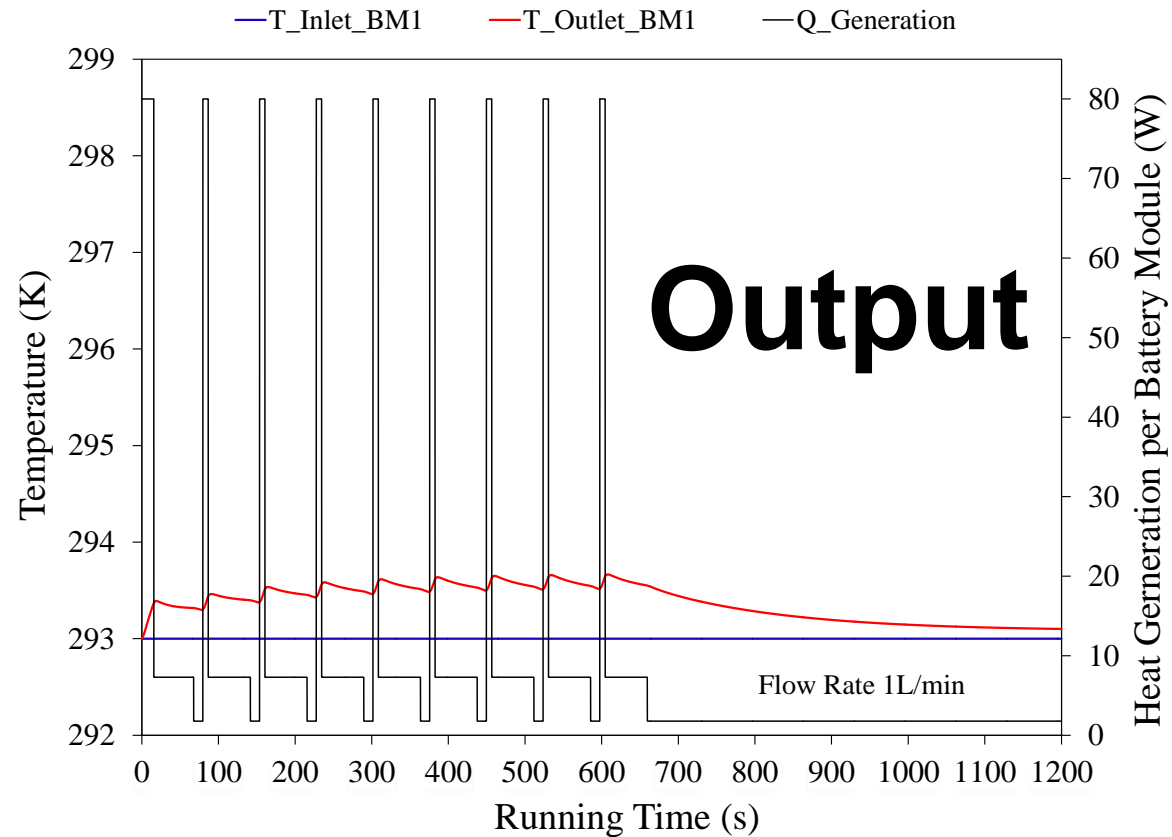
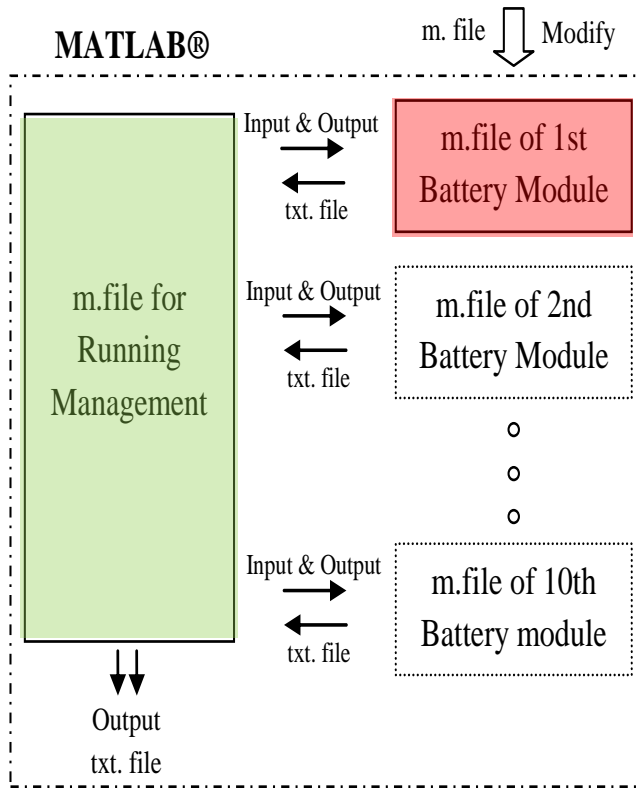
Output of First battery module

- Outlet temperature depends on heat generation of BM-1(txt.file)
- Temperatures of each battery cells (txt.file)

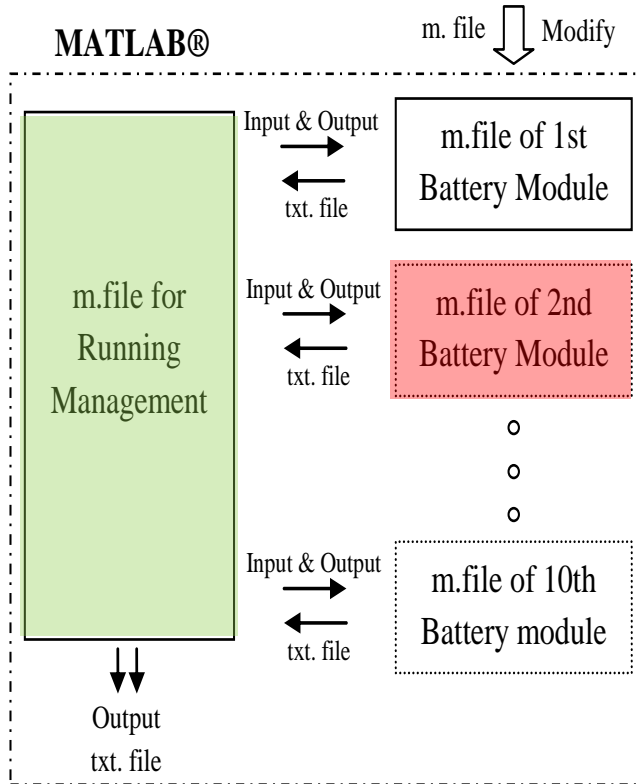
Runtime ranges between 34 to 37 hours.



MATLAB® – Finished Process BM-1



MATLAB® – Running Process BM-2

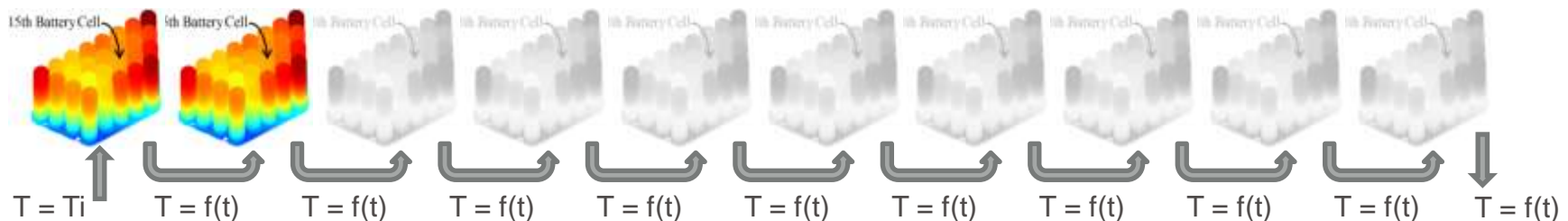


Input of Second battery module

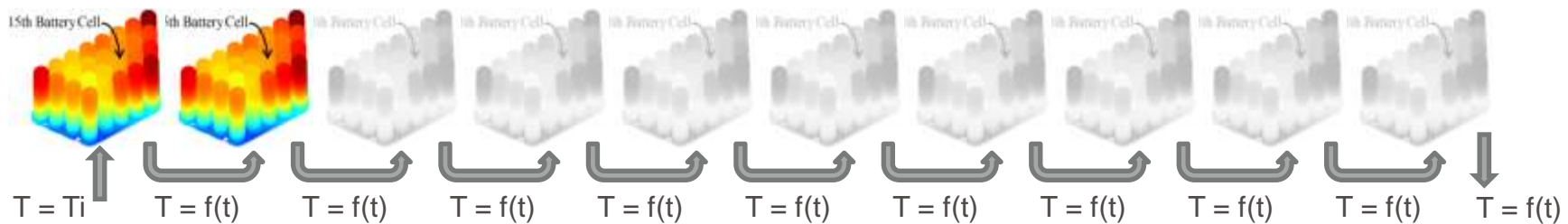
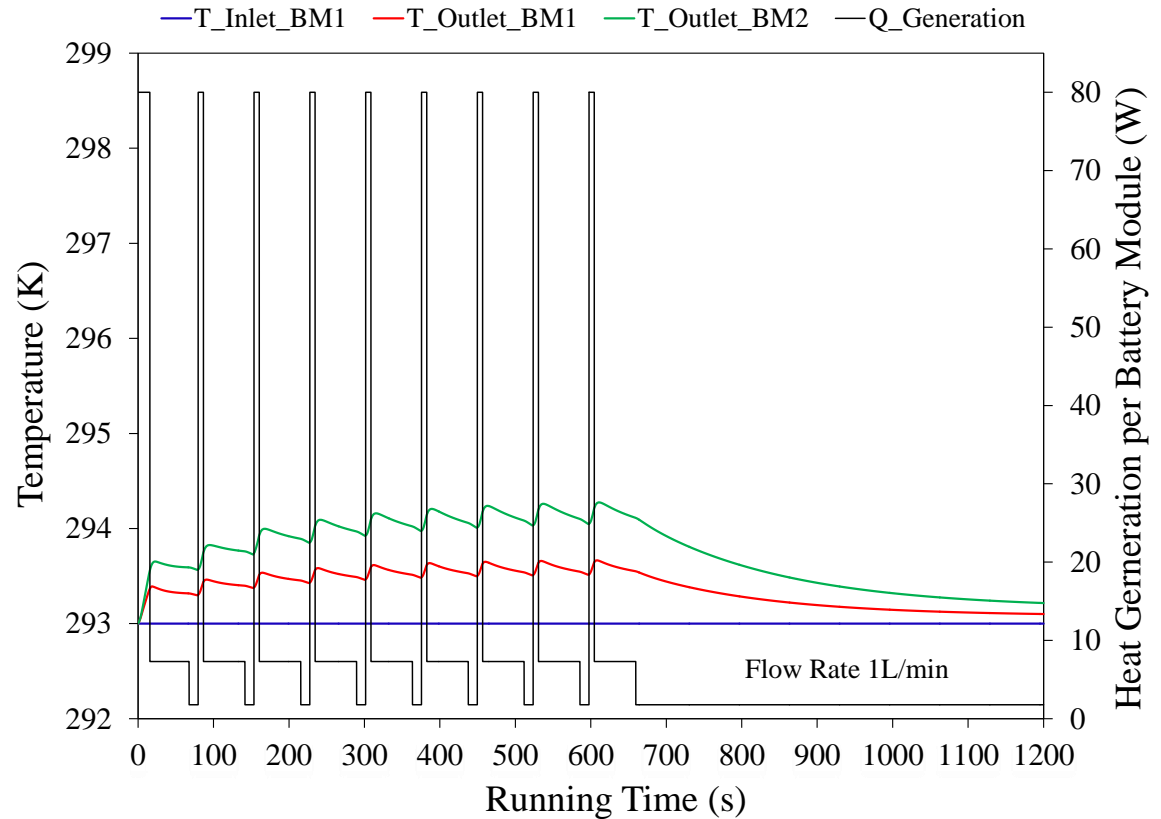
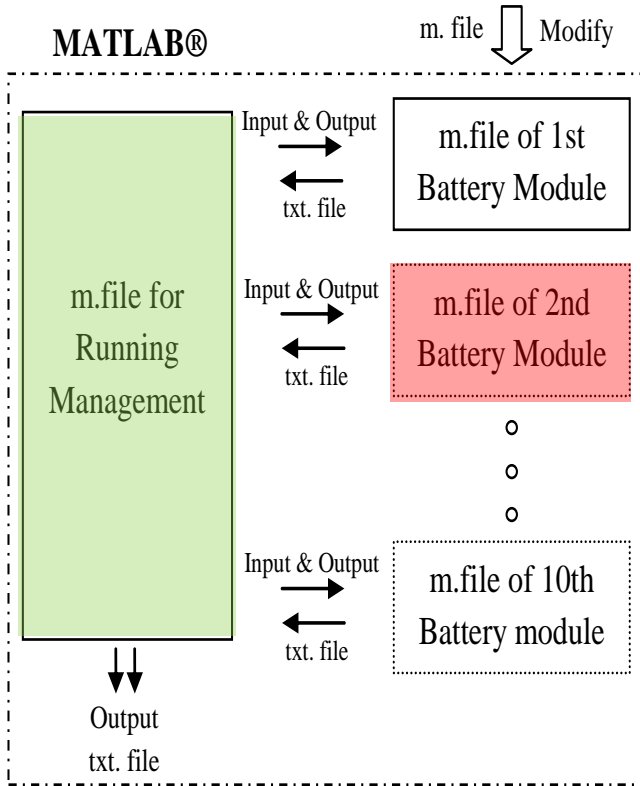
- Inlet temperature is outlet temperature of first battery module (txt.file).
- Flow rate remains constant at 1 L/min
- Heat generation as a function of time (txt.file).

Output of Second battery module

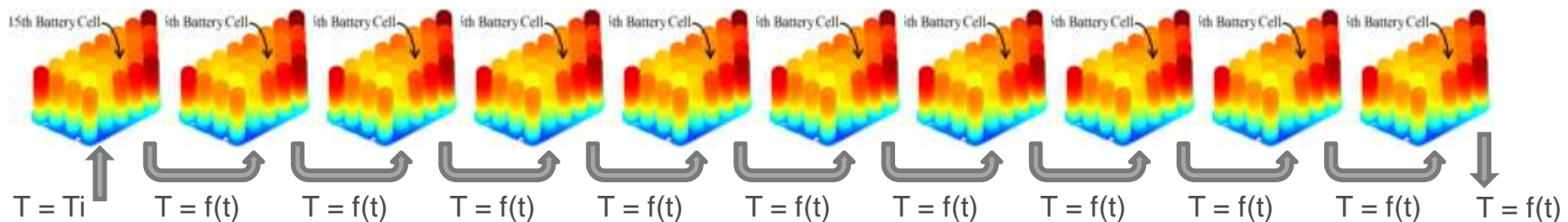
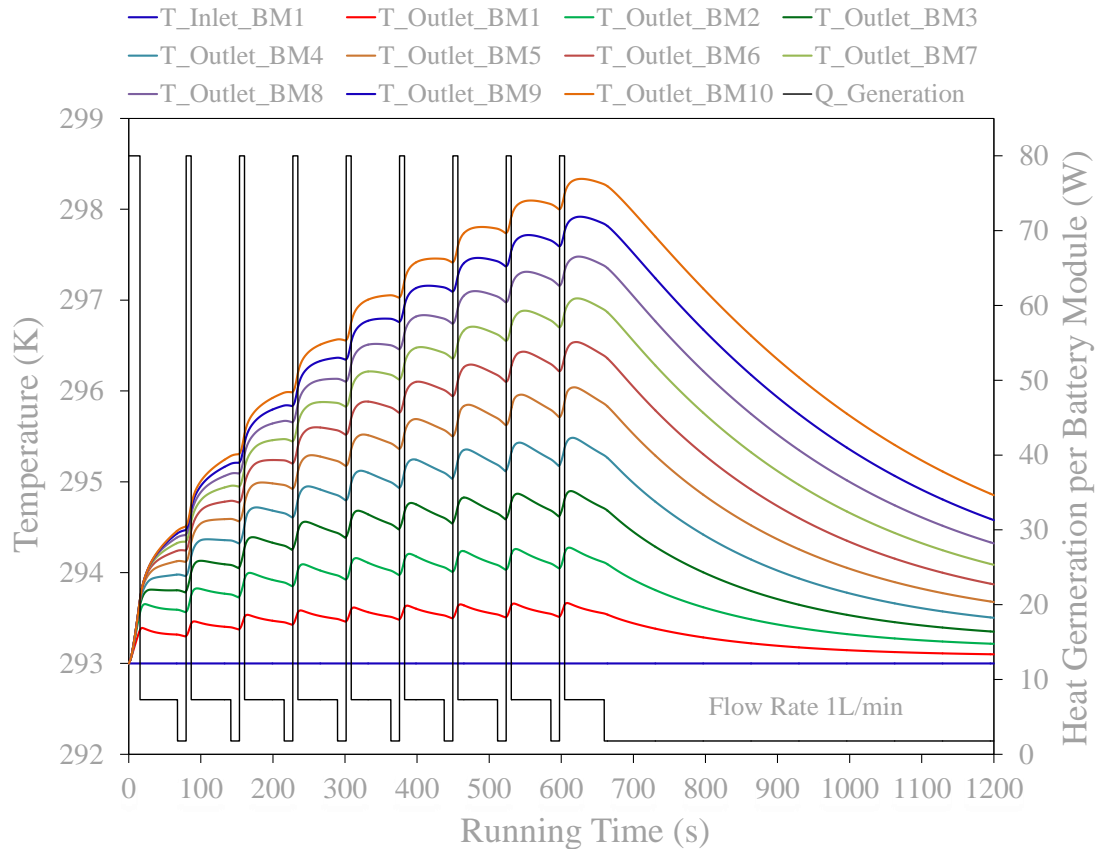
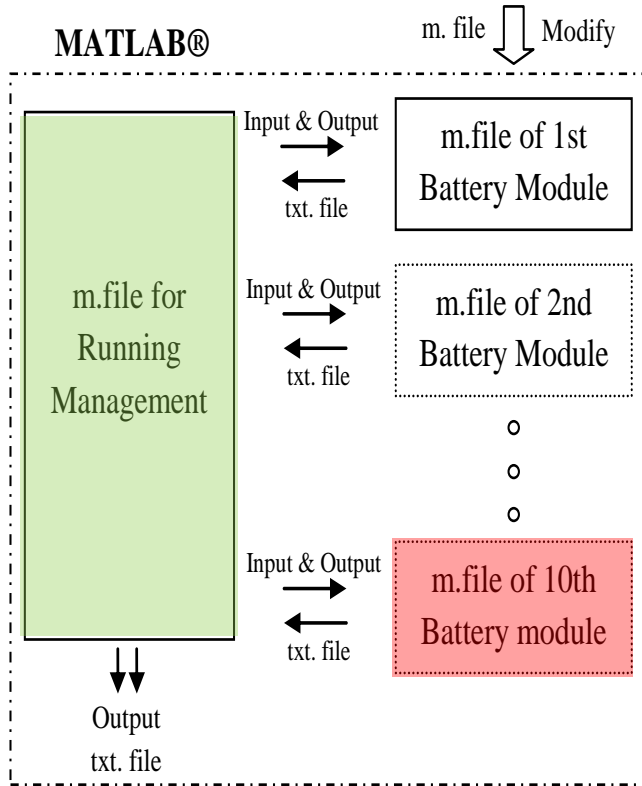
- Outlet temperature depends on heat generation of BM-1 and BM-2 (txt.file)
- Temperatures of each battery cell (txt.file)



MATLAB® – Finished Process BM-1



MATLAB® – Finished Process 10 BMs



Conclusions

- The ***m.file of the Battery Modules*** from COMSOL is able to run with the ***m.file for Running Management*** to investigate the temperature distribution of the cooling system in the battery pack
- ***Running time*** of each battery module in **COMSOL with MATLAB** is ***faster*** than **running time in COMSOL, 2 times** (Intel(R) Core (TM) i7 CPU 930 @ 2.80 GHz 2.80 GHz and 6 GB of RAM)

Furture work

The m.file of Battery Module from COMSOL will be connected with Simulink/MATLAB for Large system



***Thank you for
your attention***

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