

Study of an electric traction chain performance for person with reduced mobility in ADVISOR tool

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Abstract-- Nowadays, transportation is an inseparable part of human life. We can travel easily thanks to vehicles such as bicycles, public transportation etc..., but it still a hard job for people with reduced mobility. They usually use wheelchairs, customized cars... In this paper, we try to simulate a light specialized vehicle for needy people. We choose the advisor tool that helps us to get a better simulation and gives a traction chain, whose elements of storage and power are lighter and less expensive.

Index Terms-- Advisor, traction chain, input parameters, electric vehicle.

1. INTRODUCTION

The elements of an electric vehicle are batteries, power converter, transmission chain and the electrical motor. The software was developed to model and to simulate the vehicle, for example: Advisor 2002, Dymola, Simulation X, AMESim, and Saber... [1].

We are interested in ADVISOR tool, which has a powerful analysis tool of advanced and conventional vehicles.

Advanced Vehicle Simulator model: ADVISOR, was firstly developed in November 1994[3], and created by the American Department of Energy's National Renewable Energy Laboratory's (NREL) [3].As the tool became more and more advanced and flexible, many other clients have also used it to understand and know the system-level interactions of hybrid and electric vehicle components [2]. This modeling tool evaluates quickly the performance of conventional, electric, hybrid, and fuel cell vehicles [3].the user can change many different components of the vehicle and its specifications like electric motors, batteries, and engines [3]. Then the advisor tool simulates the vehicle's response which run on the different driving cycles [3]-[2].So it is used to make whole analysis of performances of a large range of vehicles [4].

ADVISOR uses MATLAB environment and the control of Simulink for simulations [5]. It takes the required speed

into account to follow the test-driving cycle, then determines the power, speed and required torque to be provided by the power group in order to follow the instructions. Pollutant emissions, fuel consumption, state of batteries charge, acceleration, ability to overcome slopes and analyzing the distribution of energy consumption are then calculated [1].

Advisor tool has an easy and practical graphical interface, allowing most system to troubleshoot problems (GUI) [2].

This graphical user interface is composed of three main screens (GUI) that help the user in the simulation process [6]-[2]. He can model any type of vehicle (EV/HEV...) by changing simply the vehicle configuration and parameters without modifying the Simulink block diagrams [7]. He can also evaluate the impacts of the vehicle's parameters, its drive cycle requirements, fuel economy and emissions.

The first of three ADVISOR 2.0 GUI window is the vehicle input page, through which the user can select his own vehicle configuration (serial, parallel ...) and components of traction chain using drop down menus[5], [6]. The component size (peak power and number of modules) can be changed by editing the value of characteristic shown in the boxes on the right portion of the window [7].So the auto-size button facilitates the task of sizing drivetrain components of traction chain (motor, the number of battery modules of the system, engine) to meet user-defined performance constraints of gradeability and acceleration [5]. Lastly, the scalar parameter can be modified through the "Variable Editing" button in the lower right portion of the screen [7]. All vehicle configuration parameters can be saved for later uses [6]. When the user is satisfied of his own vehicle, he moves to the second advisor GUI window via the "continue" button [7], to simulate the vehicle on a standard cycle, which is used to estimate fuel consumption and pollutant emission

of a vehicle, so we can compare the difference between the vehicles [5]. Therefore in the ADVISOR simulation setup window the user selects the cycle and defines the simulation parameters in the right portion of the screen [7]. When all measure are fixed, the user moves to final advisor window through the "run" button which start the simulation and the results will be shown in this results window[6]-[7]. The ADVISOR results window provides the capacity of testing the vehicle performance. , summary results such as emissions, fuel economy, results of different tests (maximum gradeability and acceleration) are displayed on the right part of the screen [6].

2. MODEL OF ALL ELECTRIC VEHICULE IN ADVISOR

There are many configurations of vehicles in advisor tool (series, parallel, electrical...), described above. In this paper, we chosed the electrical configuration, which is the most adequate for a light application [6].

As appears in Fig. 1, the traction of All-electric vehicle is composed of a battery, electronic power (inverter), an electric motor, an on-board charger. All-electric vehicles run only on electricity [6]. They are propelled by one or more electric motors powered by rechargeable battery packs.

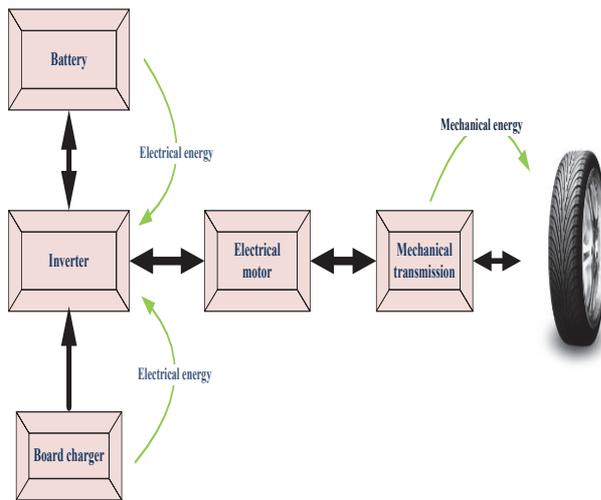


Fig. 1. General schema of electric vehicles

3. SIMULATIONS AND RESULTS

A. Input parameters

To begin the simulation with ADVISOR tool, two main parameters must be identified, which are the acceleration and gradeability. The two latter allow the user to define the performance constraints of his traction chain [8]-[9].

As appears in Fig. 2, Fig. 3, via the Grade Options and Accel Options buttons, user can specify the performance constraints that can be applied in sizing the vehicle.

The user will be able to change a set of parameters, as he desires.

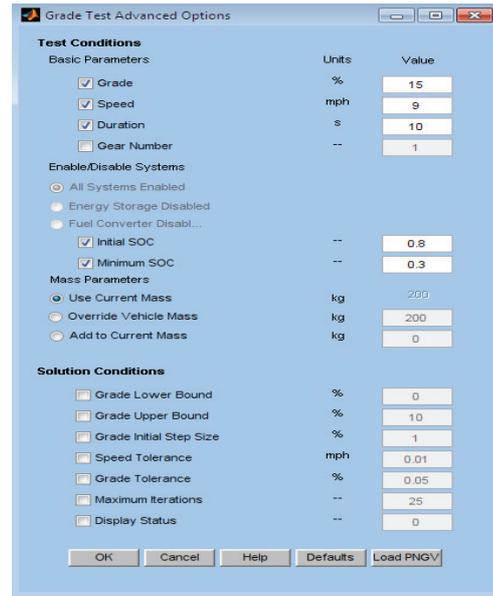


Fig. 2. Grade parameters

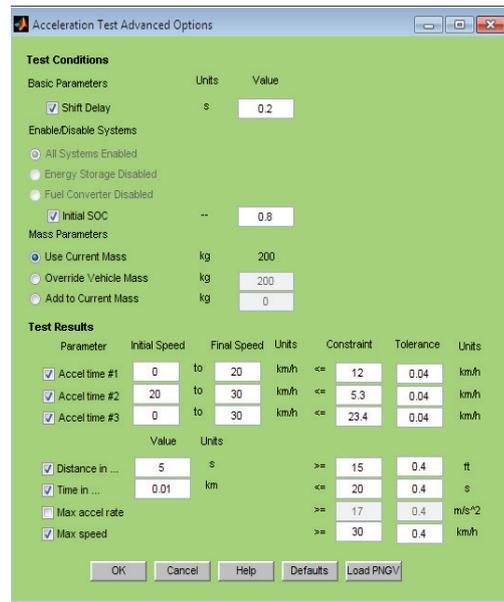


Fig. 3. Acceleration parameters

- Acceleration

In the following TABLE I the values of acceleration parameters are shown [8].

- Gradeability

The gradeability put in perspective the ability of a vehicle to overcome the slopes. In the following TABLE II, the values of grade parameters are shown [8].

TABLE I
Values of acceleration parameters

Parameters	Value
Initial SOC	80%
Mass	200 kg
Accel time 1 from 10 to 20	10 s
Accel time 2 from 20 to 30	12 s
Accel time 3 from 0 to 30	23.4 s
Distance in 5s	15 feet
Time in 0.01km	20s
Max speed	30 km /h

TABLE II
Values of gradeability parameters

Parameters	Value
Grade	15%
Speed	9 mph
Duration of the grade	10 s
State of initial load (I_SOF)	80%
Minimum state of charge (m SOF)	30%

When the step of adjustment parameters of acceleration and gradeability constraints is finished, we move to self-dimensioning step. The component sizes are minimized on this step [8]. The number of battery modules is reduced; the driving power is minimized, which influences on vehicle mass as well as on price. After the selection and sizing the various components of the vehicle. It remains only to test the vehicle on a standard cycle for performance analysis of the traction chain [9].

B. Simulation with first value of slope

For our traction chain, we choose for energy storage: the battery type lead, which is not expensive .And according to simulation results and performance constraints, we choose the motor. Therefore, the simulation is performed with two types of motors: synchronous and asynchronous motors with the same number of lead battery modules.

The Fig. 4 shows the all-electric vehicle traction chain, which is modeled with Simulink [9]. This block diagram represent how ADVISOR applies the drive cycle and vehicle properties to analyze the power flow [9].

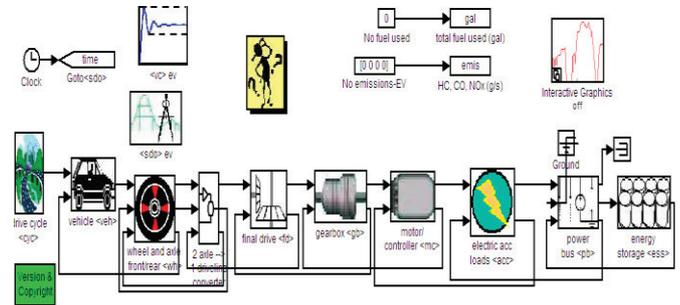


Fig. 4. Traction chain of the all-electric vehicle

• *Simulation with asynchronous motor*

The elements of the traction chain are selected. Therefore, the next step is the sizing of these latter. The result of simulation auto size is shown below:

Grade test ... SUCCESSFUL!
 Acceleration test ... SUCCESSFUL!
 Motor/controller ==> 3 kW
 Energy storage system module number set to minimum number of modules!
 Energy storage system number of modules ==> 8
 Final drive ratio ==> 5.0579 to allow max speed of 18.6411 mph.
 Total vehicle mass ==> 200 kg.

The following TABLE III recapitulates the values of the various parameters concerning our traction chain like the result of auto size, weight of some components etc...

TABLE III
Summarize of some values of traction chain with induction motor

	Asynchronous Motors	ESS (lead battery)
Number of module		8
Weight	9kg	51kg
Voltage	Min voltage=70V	99v
Power	3kw	
Max speed	30km/h (Simulation result: 30.6km/h)	
Vehicle weight	200kg= weight of (driver + chassis+wheel+battery+motor...)	
Grade	15 % (Simulation result: 19, 1%)	

ECE driving cycle is the cycle chosen for testing the different traction chain in our application. This latter is an urban European driving cycle, it is characterized by a low speed (maximum speed = 50 km/h)[9].

The main outputs from the ADVISOR simulations were plots showing the SOC as a function of time and velocity profile [9]. In Fig. 5 the result of our vehicle simulation that run on the ECE driving cycle, is illustrated below.

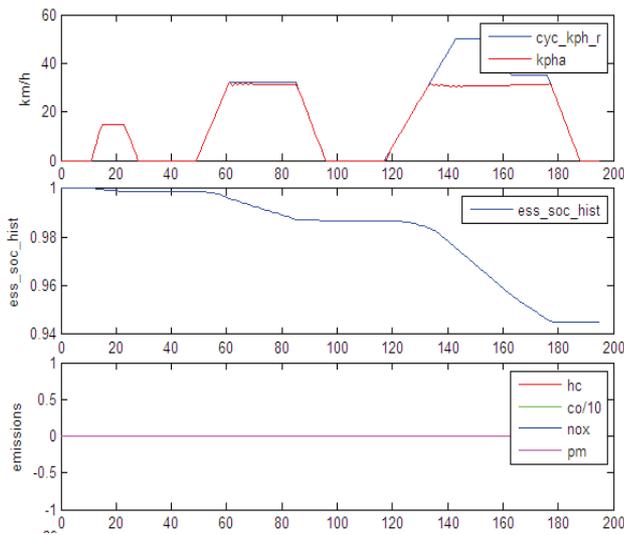


Fig. 5. Test of traction chain with asynchronous motor on ECE driving cycle

This traction chain with induction motor power (with 3 Kw), and eight number of lead battery modules, is able to reach a maximal speed up to 30.5 km/h and 19.1% of slope.

- *Simulation with synchronous motor*

The result of simulation auto size is shown below:

Grade test ... SUCCESSFUL!
 Acceleration test ... SUCCESSFUL!
 Motor/controller ==> 3 kW
 Energy storage system module number set to minimum number of modules!
 Energy storage system number of modules ==> 8
 Final drive ratio ==> 3.8824 to allow max speed of 18.6411 mph.
 Total vehicle mass ==> 200 kg.

In the following TABLE IV are saved the result of auto size and a set of parameter values related to our chain.

In Fig. 6 is illustrated the test of vehicle on the ECE driving cycle.

TABLE IV

Summarize of some values of traction chain

	Synchronous motor	ESS (lead battery)
Number of module		8
Weight	4kg	51kg
Voltage	Min voltage=49V	99v
Power	3kw	
Max speed	30km/h (Simulation result: 48km/h)	
Vehicle weight	200kg= weight of (driver + chassis+wheel+battery+motor...)	
Grade	15%(Simulation result: 31, 4 %)	

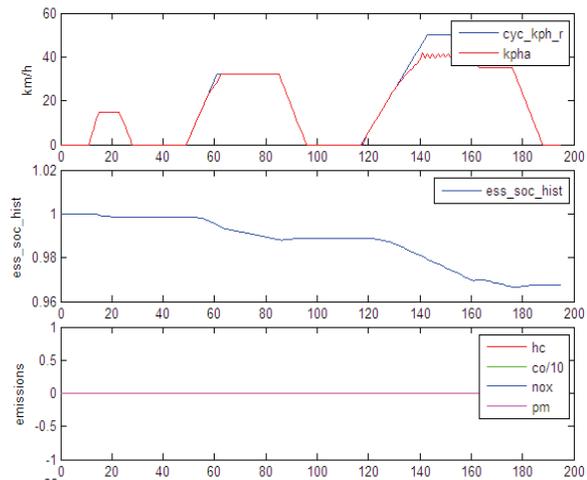


Fig. 6. Test of traction chain with synchronous motor on ECE driving cycle

This traction chain with synchronous motor power (with 3 Kw), and eight number of lead battery modules, is able to reach a maximal speed up to 48 km/h and 31,4% of slope.

C. Simulation with second value of slope

Now we just change the grade parameters and then we will notice the effect on the traction chain. In the TABLE V is shown this change.

TABLE V
Grade parameters

Parameters	Value
Grade	12%
Duration of the grade	10s
State of initial load (I_SOF)	80%
Minimum state of charge (m SOF)	30%

- Simulation with asynchronous motor

The result of simulation auto size is shown below:

Grade test ... SUCCESSFUL!
 Acceleration test ... SUCCESSFUL!
 Motor/controller ==> 2 kW
 Energy storage system module number set to minimum number of modules!
 Energy storage system number of modules ==> 6
 Final drive ratio ==> 5.0579 to allow max speed of 18.6411 mph.
 Total vehicle mass ==> 200 kg

The result of auto size and the set of parameter values related to our chain are revealed in the following TABLE VI.

TABLE VI

Summarize of some values of traction chain with asynchronous motor

	Asynchronous Motors	ESS (lead battery)
Number of module		6
Weight	6kg	38kg
Voltage	Min voltage=70V	74v
Power	2kw	
Max speed	30km/h (Simulation result: 31 ,2km/h)	
Vehicle weight	200kg= weight of (driver + chassis +wheel+battery+motor...)	
Grade	12 %(Simulation result 12, 4 %)	

In Fig. 7, shows us the result of vehicle simulation running on the ECE driving cycle

This traction chain with induction motor power (with 2KW), and eight number of lead battery modules, is able to reach a maximal speed up to 31, 2 km/h and

12, 4% of slope and furthermore we notice that the vehicle follows correctly the ECE driving cycle for a speed lower than 31, 2 km/h.

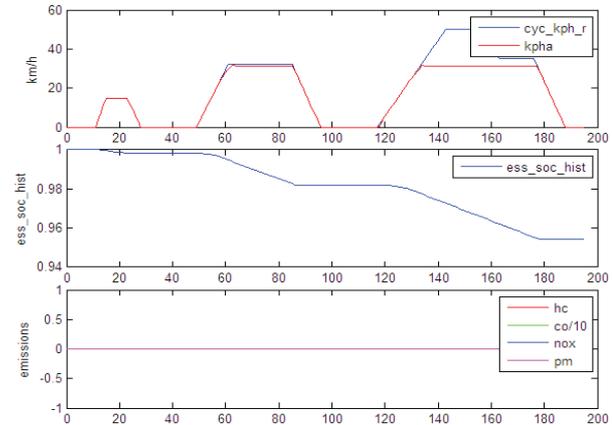


Fig. 7. Test of traction chain on ECE driving cycle

- Simulation with synchronous motor

The result of simulation auto size is exposed below:

Grade test ... SUCCESSFUL!
 Acceleration test ... SUCCESSFUL!
 Motor/controller ==> 2 kW
 Energy storage system module number set to minimum number of modules!
 Energy storage system number of modules ==> 6
 Final drive ratio ==> 4.9916 to allow max speed of 18.6411 mph.
 Total vehicle mass ==> 200 kg

The result of auto size and the set of parameter values related to our chain are revealed in the following TABLE VII.

TABLE VII

Summarize of some values of traction chain with synchronous motor

	synchronous Motors	ESS (lead battery)
Number of module		6
Weight	2kg	38kg
Voltage	Min voltage=49V	74v
Power	2kw	
Max speed	30km/h (Simulation result:37 ,4 km/h)	
Vehicle weight	200kg= weight of (driver + chassis +wheel+battery+motor...)	
Grade	12 %(Simulation result 24, 4 %%)	

The Fig. 8 shows us the test of vehicle on the ECE driving cycle.

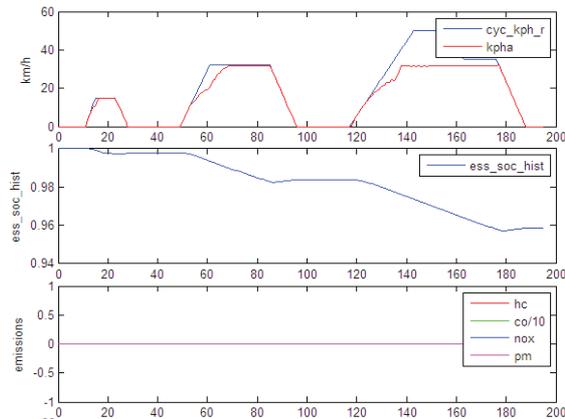


Fig. 7. Test of traction chain on ECE driving cycle

This traction chain with 2Kw the power of its induction motor, and eight number of lead battery modules, is able to reach a maximal speed equal to 37,4 km/h and overcome a slope equal to 24,4 %).

E. Recapitulation

The results obtained for simulation are shown in the following table:

TABLE VIII
Simulation result

	Simulation results with 12%of slope
Simulation with induction motor	
Simulation with synchronous motor	

We notice that when the slopes decreases, the motor power reduces also the module numbers of battery, which has an impact on the vehicle mass as well as the price. This is shown especially with a slope of 12%.

The results demonstrate that the traction chain with induction motor answers correctly to the performance constraints (acceleration, slope ...). In addition, this traction chain followed correctly the ECE driving cycle than that one with synchronous motor for the speeds lower than or equal 30km/h.

4. CONCLUSION

In this paper, the ADVISOR is a powerful analysis tool of advanced vehicles, which take as input parameters: acceleration and gradeability, to estimate the size of vehicle components. Simulation results indicate that a traction chain with asynchronous motor, for the low value of the slope, is the best for this application thanks to its price advantage, weight and autonomy.

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