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ELECTRIC DRIVE SYSTEM BEHAVIOR SIMULATION AT THE FORESTIER CABLEWAY

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Abstract

This article is a small part of the overall research on the electrification of a forest funicular. We live in a world that is constantly working to reduce pollution caused by the use of fossil fuels, and this is true in all fields of work. The Forestier funicular is also part of an important field of work, and because it is a complex mechanical and hydraulic system, it requires more electrical simulation to find the most optimal options for replacing the traditional thermal engine-based system. This article will look at the two main components of electrification: batteries and electric drive motors.

Key words: forest funicular, electric motor, engine cableway system

1. Introduction

The construction of access roads in the logging industry has a negative impact on the entire forest ecosystem, particularly in the case of high-slope hills or mountains. When the slope exceeds a certain value, national and international legislation recommends the use of alternative log transportation systems [1].

Forest cableways, which are used for clear cut or selective cutting in hilly or mountain terrains, are one of the most used solutions. These installations are typically made up of cable drums driven by mechanical power units and mounted on mealy sleds, allowing the system to self-propel to the point of operation, which is usually at the top of the slope [2].

2. Electrical system simulation

A parallel hybrid model was developed based on the system-level simulation model developed earlier in the project, in which the electric motor and thermal engine drive a pair of hydraulic pumps. This model was parameterized in order to simulate a system as close to the one that will be built as part of the project as possible; it will be improved in subsequent stages.

To begin, with the selection of batteries to be implemented in the hybrid traction system, this solution was also implemented in the model to see how they behave, so the power source for the engine was replaced by a battery pack. A lead-acid battery from the domestic manufacturer Rombat was chosen, with a maximum discharge current of 720A, a voltage of 13.4V, and a nominal energy of 70Ah. To achieve a voltage of over 300V, 25 such batteries were connected in series. Figure 1 shows how the batteries are connected. The battery simulation blocks have three ports: two for terminals and one for receiving information from the batteries [3-5].

Amesim Simcenter, a multiphysics software, was used to simulate the system. This software will simulate the electrical, hydraulic, and mechanical components, providing us with a complete picture of what an electrified funicular is [6].

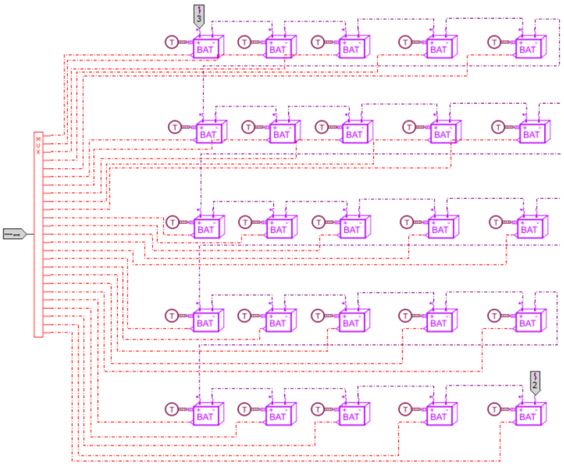


Fig. 1: Lead-acid batteries connected in series to power the electric motor

As a result, in Figure 1, the electrical connections between the batteries are represented in such a way that we have the desired level of voltage and current at the end of the simulation block [7].

The second step was to select an inverter and a motor. Based on the mechanical characteristics, a permanent magnet synchronous machine was chosen. The characteristics are depicted in Figure 2 and Figure 3. The mechanical characteristics of motor are the torque-speed characteristics because it reflects relation of torque T and speed when motor operating [8-9].

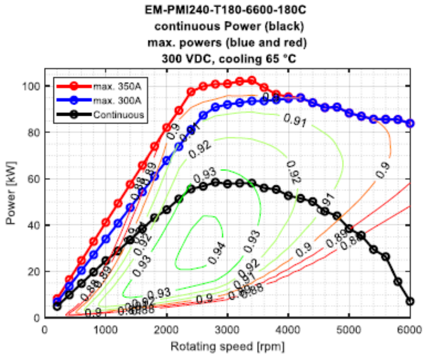


Fig. 2: Representation of power according to speed [10]

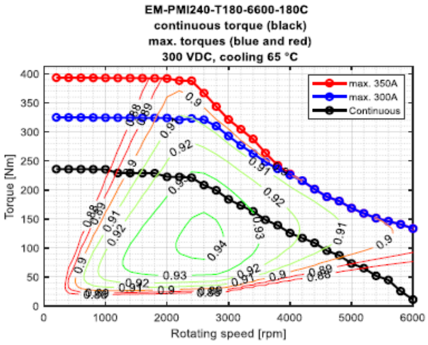
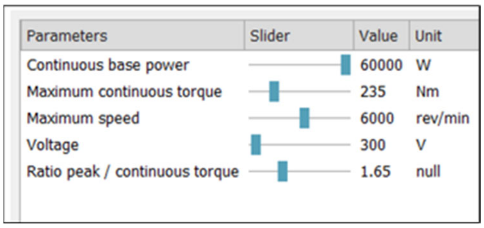


Fig. 3: The mechanical characteristic [11]

The black dotted line represents the characteristic of power and torque at nominal operation and the red and blue line are the characteristics at maximum power and torque respectively at a maximum electric current of operation. The meaning of the closed trajectories depicted in thin red/green/light green represent the boundaries to the maximum values (red) and to the nominal values (green). To characterize the electric motor, a tool found in the Simcenter Amesim program was used (Figure 4), allowing the motor to be modeled using the parameters (maximum torque, maximum speed, power supply voltage, machine power, and machine load factor) shown in the Figure 3 [12].

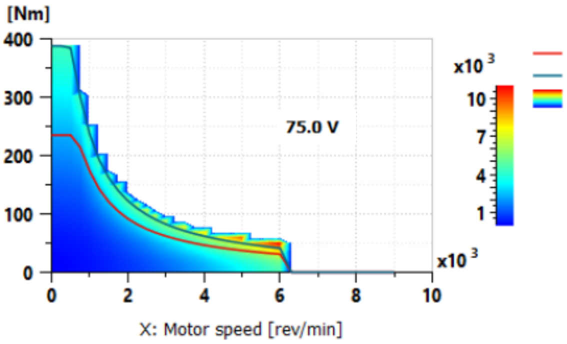


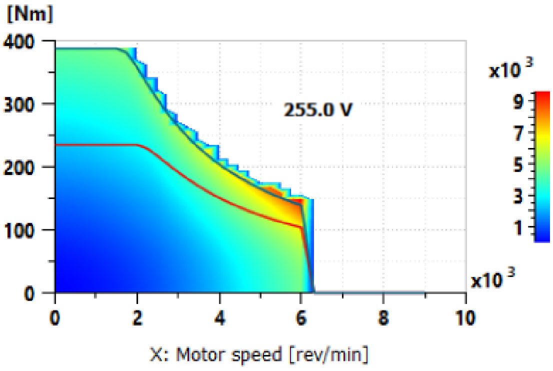
Parameters	Slider	Value	Unit
Continuous base power		60000	W
Maximum continuous torque		235	Nm
Maximum speed		6000	rev/min
Voltage		300	V
Ratio peak / continuous torque		1.65	null

Fig. 4: Parameterization of the electric motor in Amesim

3. Results

The program automatically generates the mechanical characteristics and efficiency map of the electric motor based on these parameters, as shown in the figures below. These characteristics are generated for a variety of voltage levels that can be used to power the electric motor. Simcenter Amesim generates a characteristic that is consistent with the manufacturer's specification.





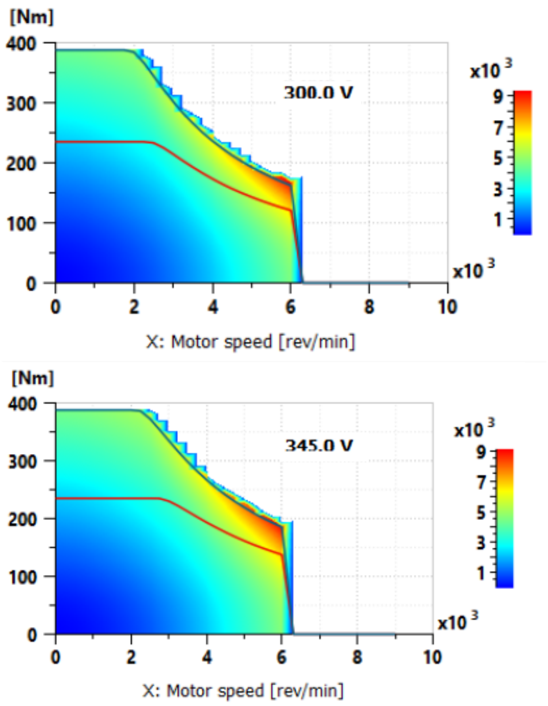
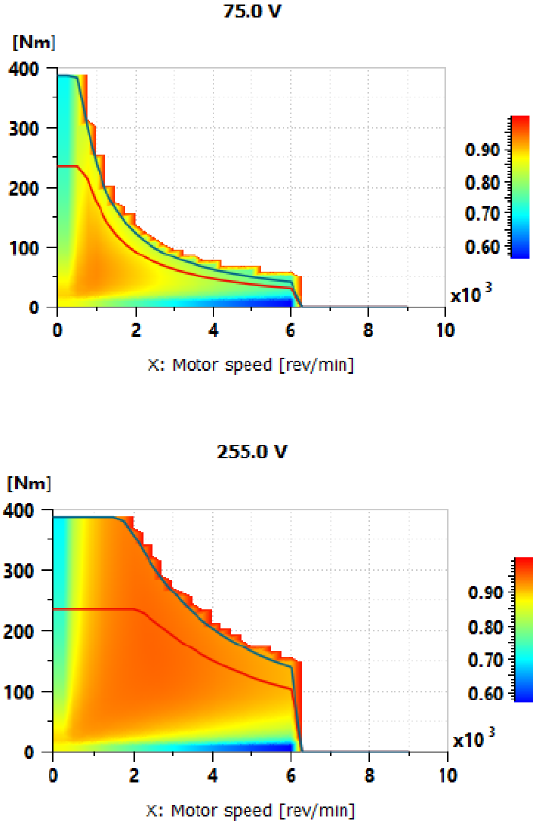


Fig. 5: The mechanical characteristics generated in Simcenter Amesim for the traction motor.

The efficiency map generated in Simcenter Amesim for the traction motor is shown in the figures below.



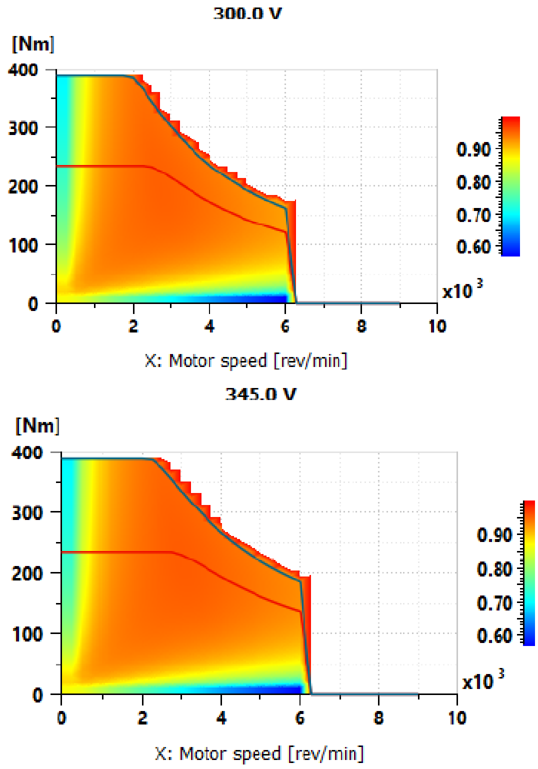


Fig. 6: The efficiency map generated in Simcenter Amesim for the traction motor

An efficiency map for an electric machine is a contour plot of the electrical machine efficiency on axes of torque and speed. It describes the maximum efficiency for any speed/torque combination and is a convenient way to represent the motor drive over a range of operating points defined by a cycle [12]. Both for the mechanical characteristics generated and for the efficiency map, the characteristic in red and blue represent different values of the respective torque from a normal operating value to the maximum value (blue). The map shows us that the engine has maximum efficiency in the area with shades of red and is decreasing until the area with shades of blue at different supply voltages.

4. Conclusions

All these obtained results will be further implemented in the development of this forestry funicular, which is also based on an electric motor for pulling the cable from which the tree trunks are hung.

When designing an electric motor for a specific application, we must consider the mechanical properties of the load; thus, simulations must revolve around determining the mechanical properties of the motor for it to cope with the required load. Its efficiency is also important because we want the funicular's energy consumption and overall consumption to be as low as possible, resulting in reduced efficiency and as little pollution of the ecosystems as possible.

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