Comparison of the Propulsion of Electric Vehicles for Passenger Cars and Buses in Terms of Efficiency Optimization

István Bendiák and Tamás Sándor

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István Bendiák
University of Óbuda Kandó Kálmán Faculty of Electrical Engineering Institute of Automation
Budapest, Hungary
bendiak.istvan@uni-obuda.hu

Tamás Sándor
University of Óbuda Kandó Kálmán Faculty of Electrical Engineering Institute of Instrumentation and Automation
Budapest, Hungary
sandor.tamas@uni-obuda.hu

Abstract— **The topic of the article is to optimize the efficiency of electric vehicles, which takes into account all environmental factors. There are a number of types of factors that need to be tackled while the vehicle is moving that reduce the energy efficiency of the driving cycle. Numerous publications [1-19] deal with this area and we have found a solution for how it should be implemented.**

Keywords—efficiency map, intelligent current limit, acceleration limitation, efficiency-oriented

I. INTRODUCTION

The scientific literature extensively discusses the variants of the efficiency map of synchronous machines and reluctance machines, and relates them to machine construction.

The present research is also moving in this direction, the current significance and versions of the results should always be reviewed. I consider the introduction of decision quotients to be advantageous when examining the nature of the effects, which points in the direction of novelty.

The method described in the eighth chapter can be used to start in the direction of the intelligent current limit. The LabView model includes a cycle that uses the formulas shown to calculate the current demand for the torque generated during the shift.

The torque-current limit in synchronism with the efficiency-oriented intervention is an increased requirement for the calculation and selection of the load curve set.

According to the present position, using the Labview model, it was necessary to create a calculation suitable for calculating the flux value to be provided for torque generation. Scientific publications are also exploring this range along with field weakening. This part is available due to the reduction of the vehicle's acceleration torque, but is not necessarily the authoritative aspect for the bus due to the acceleration limitation.

The pre-calculated current demand developed for the twin drive helps to set the current limit for the next cycle. The current limit here does not refer to transient phenomena, but to assess the power coordination of the two drive motors.

Flux calculator machinery model: An important role in modeling was the regulation of constant flux, which also examines the presence of flux reserve. Flux reserve means how much flux present in a machine and how it changes can be maintained by a voltage intervention. If there is a spare, what limit can be increased, or if the machine is too forced, it can be reset. The process is machine dependent. The parameters of the synchronous machine determine the extent to which this is allowed. The advantage of twin propulsion is that the two motors are able to take loads from each other, so that said process can be reduced.

The intelligent torque current limit must be handled in conjunction with efficiency-oriented intervention calculations, in part it can be handled independently, but ultimately not, because the efficiency range loses its value and must be related to all environmental parameters.

II. EFFICIENCY MAP

A. *Load Curve Calculation (Performance Test)*

In the case of electrical machines, the complete calculation of the efficiency map [8-10] is of paramount importance. Calculation of the load curve for different control modes. Constant flux and variable flux method, field weakening range monitoring, Depending on what kind of driving cycle the engine should provide.

B. *The issue of magnetic energy*

The magnetic energy accumulated in the machine is the flux integral of the current flowing in the coil.

In the case of hysteresis phenomena and neglect of eddy currents, the magnetization curve and thus the magnetic energy in a given position of the rotor is a monovalent function.

I use a capital letter to denote magnetic energy, even though the time variable is therefore an instantaneous value.

$$W_{\text{magnetic energy}} = \int_0^{\Psi} i d\Psi$$

where,

i-armature current

ψ-Main flux

III. EFFICIENCY OPTIMIZATION ISSUES

Adding an efficiency map [1-10] shows a consequence of the condition of the drive motor. It is an option for artificial intelligence-based intervention, but a kind of output state due to motor control.

The drive motor is deflected from its nominal operating range, its efficiency will deviate from the prescribed state, one of the possibilities of its optimization is the continuous examination of the efficiency characteristic curve, which is a known procedure in the scientific world, but during the research I came up with the following idea.

- Torque calculation should be treated in conjunction
- The field weakening range should be monitored separately
- The vehicle engine must always be at the correct efficiency map
- • Variable motor parameters
- • Variable gear ratio and efficiency
- • Variable frequency range (drive inverter)
- • Adjustable time constants (electrical and mechanical)
- • Measurable, variable loss components

In the case of vehicle drives, due to the ever-changing speed and torque requirements, the control methods must be combined with efficiency-oriented optimization, but must be supplemented by a decision map that defines the operating phases of the machine.

The flux required to generate torque in the machine is a primary consideration to keep it on the right efficiency map.

$$\Phi = \int_0^A B \cdot dA$$

where A is the total area of the surface in meters squared, dA is a differential of area.

IV. SETTING CURRENT SURGES AND CURRENT LIMIT

Approaching the current limit, taking into account mechanical requirements for the case of a rotating machine, if I assume the power transfer to the gear unit or driven equipment is ideal, then:

$$T_1 \cdot \omega_1 \cong T_{gearbox} \cdot \omega_{gearbox}$$

where

T_1 = first motor torque

ω_1 − first motor angular velocity

M_2 second engine shaft torque

From the point of view of the drive motor, this means that the mechanical shifts will cause a current transient, according to which:

$$T = K_t \cdot \Phi \cdot I_a$$

where,

T − motor torque

ϕ − motor flux

I_a − armature current

K_t − motor constant

According to the torque generation relationship, assuming constant flux during switching.

Which means that due to the changing speed, the torque demand will also change.

In this case, a separate current transient monitoring cycle is required for the synchronous machine, the distribution of which must be examined over time depending on the inertia to be accelerated and decelerated.

A. *Twin drive concept*

Transient-free load transfer is required between the motors.

This means that the current is determined by the torque required by the gear unit, the angular velocity, the torque constant of the motor, the flux of the machine and the angular velocity of the drive motor.

$$T_{motor1} = K_t \cdot \Phi_1 \cdot I_{a1}$$

where,

T_{motor_1} = first motor torque

ϕ_1 = first motor flux

I_{a_1} = first motor armature current

Torque generation of second engine:

$$T_{motor2} = K_t \cdot \Phi_2 \cdot I_{a2}$$

T_{motor_2} = first motor torque

ϕ_2 = second motor flux

I_{a_2} = second motor armature current

In the case of twin drive, according to the shift and the required speed, the gear shifting can cause an electric shock in both motors. The torque delivered by the two motors also requires an extremely [1-3] wide control structure, because by using and primarily developing the control of permanent magnet synchronous machines, the delivered torque and efficiency can be optimized.

B. *Development directions and shortcomings of the machine model*

In the basic model, the [1-5] iron loss of the drive motor is calculated on the basis of a power chain curve, giving an incorrect value at given load points due to a wide range of additional motor losses, which can only be approximated without the loss ratio of the iron pack.

- Battery heat loss rate, loss estimate based on internal resistance modeling, recharging to battery
- Calculation of heat loss on the inverter for both open and switching frequency-dependent losses
- Calculation of heat generated by coil and iron loss on motor
- Calculation and monitoring of the gear loss factor
- As well as calculation, comparison, systematization and transmission of all loss components for the entire driveline to artificial intelligence.
- Gear switching transient test with pre-programmed method
- Calculation of twin drive power chain curve
- Transmission gear transient monitoring system
- Gear switching matrix, switching sequence
- Twin drive control methods, priority order research (current, voltage, frequency, speed controls)
- Measuring the time functions and overshootings of gear changes by means of simulation
- Road condition, ascent, slope, cornering test (tested in a separate model)
- Travel time calculation, weather, outdoor and indoor temperatures calculation

C. *Optimal Working Point Concept*

a) . Setting the current limit will also mean a torque limit due to the [5-12] decreasing flux. In the case of control for constant torque or constant power, the previously discussed torque and angular velocity relationships determine the intervention. Defining a current limit and thus ensuring better efficiency raises the following facts:

b) Constant flux control

c) Variable flux control

d) DC control

e) Constant angular speed control

f) Constant torque control

g) Control for T · ω with a constant range (not crossing a given area)

h) Implementing the listed options requires the following additional features:

i) The listed parameters must be grouped according to priority!

j) If there is a constant flux, a voltage reserve must be formed!

k) The voltage reserve above the nominal value cannot be permanently increased!

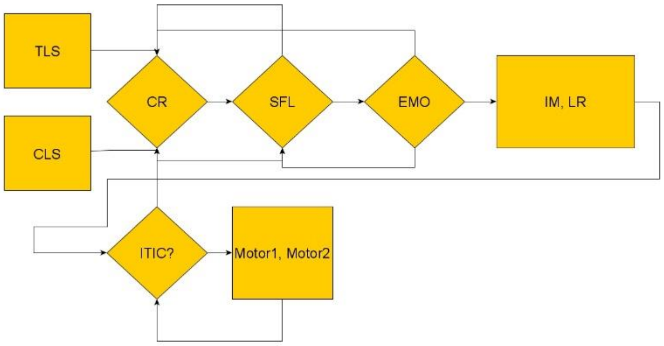

Fig. 1. . Optimal Working Point Concept

Figure 1. Means,

TLS-Torque Limit Setting (Value to set)

CLS-Current Limit Setting (Value to set)

CR-Collecting Result (Condition to be decided)

SFL-Suitable for Load (Condition to be decided)

EMO-Efficiency Map Oriented (Condition to be decided)

IM-Entervention Method (Continuous calculation)

LR-Load Recalculation (Continuous calculation)

ITIC-Is the intervention Correct? (Condition to be decided)

Motor1- Drive motor 1 (PM Synchronous Machine)

Motor2 Drive motor 2 (PM Synchronous Machine)

There will be intelligent [13] current limiting is to be implemented, a complex control task must be created first. This process prepares for a higher level of adaptive-based intervention. Motor identification must be performed to set the current limit.

In each case, the motor data is also received by the inverter and used by the control circuit to prepare the control task.

- Control mode
- Torque constant
- Setting a current limit or current limit
- Inverter voltage level selection
- Inverter frequency setting
- Voltage is constant
- Internal motor resistance

CONCLUSION

The loss model should be treated separately and together in the system, they can only be separated to the extent that it does not hinder the corrective calculations. The temperature dependence of copper, the type of gear lubricant and the temperature dependence must be included in the model.

Overall, the model is suitable for generating preliminary parameters for a simplified electric vehicle, which helps to support a longer development cycle. The voltage drop of the battery adversely affects the dynamic properties, therefore, the current limit then assumes a value that gives feedback to the data processor on the one hand and tries to follow the most optimal current range on the other hand.

The current limit setpoint [13-19] setting is not only determined by the rated current of the drive motor, if an accelerating torque is to be provided if required, the limit can be adjusted. However, this is only possible if the limits to be set are not exceeded. Current plays a key role in torque generation, so it is not possible to clearly separate the two methods (torque and current limit).

The aim of this process is to always have the selected current limit closest to the section of the load curve, ie the motor does not fall out of the optimal efficiency range.

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