

Agricultural Tractor with Pure Electromechanical Drivetrain

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ABSTRACT

The work presents the design of a traction electric equipment set of an electromechanical drivetrain (EMD) to be used with 300-hp-class agricultural wheeled tractors. Comparative characteristics of various drivetrain types used in agricultural tractors are presented; and the advantages of using EMDs in tractors are discussed. The EDM advantages are as follows: improved technical and economic parameters of the tractor; reduced dynamic loads on the tractor and diesel units; reduces wheel slippage; reduced fuel consumption (by up to 30%); continuous variation of speed of the tractor and aggregated implements; reduced expenses on maintenance, repair and spare parts; increased total reliability, controllability and comfort; possibility to use the tractor as a power source (optionally). Considered in combination, all these advantages clearly speak in favor of using electromechanical drivetrains.

For simplicity of diagnosing and servicing, and adjusting and controlling the parameters of the equipment, a service computing system (SCS) has been developed - special-purpose software for an external personal computer. The SCS helps to adjust the settings of the control system, selectively visualize the current values of variables, store and dynamically display them in an operator-friendly form, and ensure navigation and visualization of emergency logs of the high-level controller. Additionally to the main equipment, a set of options has been developed and implemented: a self-controlled power electric station, electric drive of the front power take-off (PTO) and electric drive of the fan of the internal combustion engine (ICE).

INTRODUCTION

The Production Association “Minsk Tractor Works” (PA “MTW”) and the RUSELPROM Corp. have jointly designed a powerful wheeled agricultural tractor of classical design with an AC/AC electromechanical drivetrain.

The use of the electromechanical drivetrain (EMD) has allowed to:

- Improve the technical and economic parameters of the tractor;
- Reduce dynamic loads on the tractor and diesel units;
- Reduce wheel slippage and fuel consumption (by up to 30%);
- Ensure continuous speed variation of the tractor and its aggregated implements;
- Reduce the cost of maintenance, repair and spare parts;
- Increase the total reliability, controllability and comfort;
- Use the tractor as a self-controlled power supply source (optionally).

CONCEPT-TRACTOR WITH TEES

The conceptual prototype of the tractor ([Fig. 1](#)) with the traction electric equipment set (TEES) passed its trials in 2008. The prototype was subjected to benchmark and field tests, including comparative tillage ([Fig. 2](#)).



Fig. 1. Concept-tractor with electromechanical drivetrain



Fig. 3. Prototype tractor with EMD



Fig. 2. Field trial of the concept-tractor

Table 1 presents the results of comparative trials of the prototype tractor with EMD and a serial tractor with a power-shift drivetrain.

The trials have shown that because of the stepless speed regulation of the tractor and the use of the advanced engine control system, the productivity of the tilling implement working with the prototype tractor with EMD was higher as compared with the serial tractor by 2%, while the fuel consumption was lower by 18%.

PRE-PRODUCTION BATCH OF TRACTORS WITH EMD

After successful trials of the concept-tractor, a pre-production batch of tractors with modernized TEES was manufactured. Operational and certification tests were conducted. Parameters of the prototype tractor with EMD from the pre-production batch (Fig. 3) are presented in Table 2.

The parameters of the asynchronous motor-generator (AMG) and traction asynchronous motor (AM) of the prototype tractor with EMD are presented in Table 3 below.

The AMG and TAM are liquid-cooled; the coolant flow rate is 40 l/min. Power converters of AMG and AM are integrated in the power electronics block (PEB). Power converters are made on basis of integrated three-phase voltage inverter modules SKAI made by SEMIKRON. Their maximum effective current per phase is 300 A (effective, continuous), and the nominal DC-bus voltage is 850 V. The processor controllers TMS 320 are used for frequency control of the electric machines. The PEB is liquid-cooled; the coolant flow is 20 l/min.

The prototype tractor with EMD uses modernized units of TEES of the concept-tractor with central drive, including asynchronous electric machines (AMG and AM), power electronics block, commutation block, high level controller (HLC) and a driver's information panel. A block diagram of the TEES is shown in Fig. 4.

The AMG and AM controllers make use of the vector control system. The layout of the traction equipment is presented in Fig. 5, and a photo of the power electronics block (with removed cover) is presented in Fig. 6.

The experimental characteristic of the total drivetrain efficiency (from the ICE shaft to the output AM shaft) versus the AM rotation speed at the maximum torque and the maximum power is presented in Fig. 7.

The information panel, having seven modes of information display, is located in the driver's cabin (Fig. 8). It provides functional control of various components and systems of the electric drivetrain and the ICE.

The choice of the direction of movement is controlled by a switch located under the steering wheel with mechanical

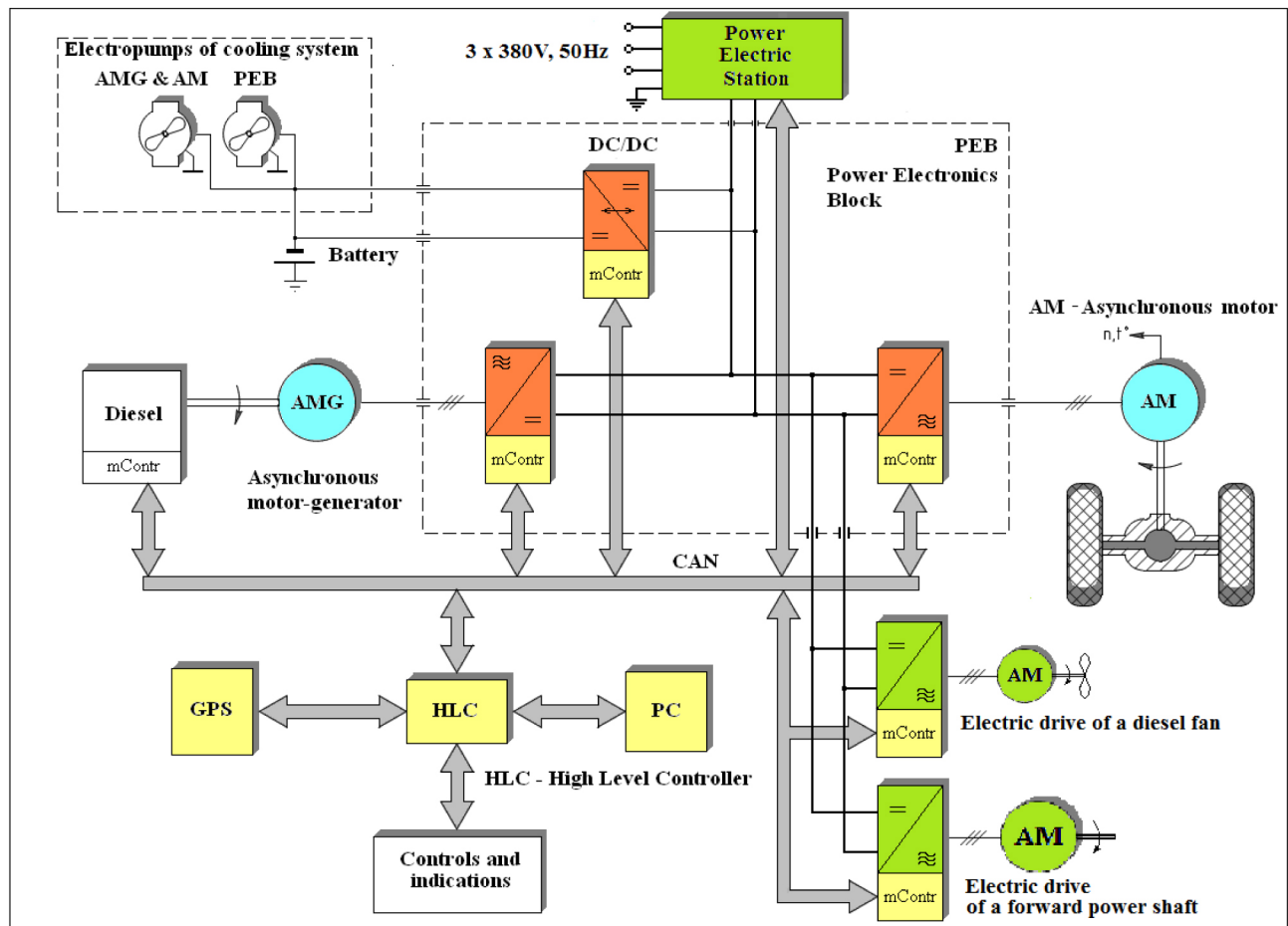


Fig. 4. Block diagram of the TEES of the prototype tractor with EMD

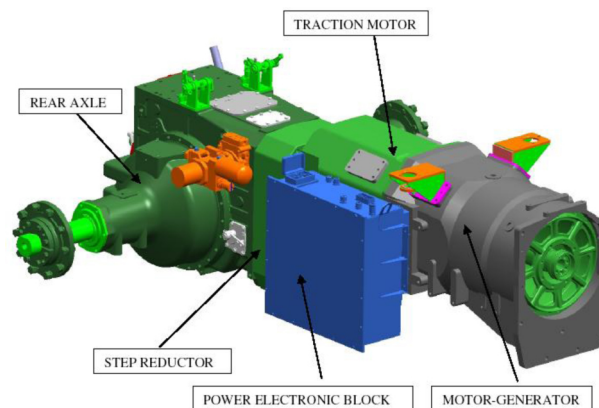


Fig. 5. Layout of traction equipment on the tractor

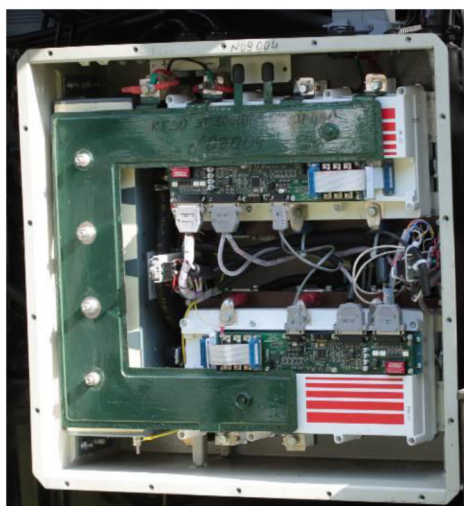


Fig. 6. Photo of the power electronics block

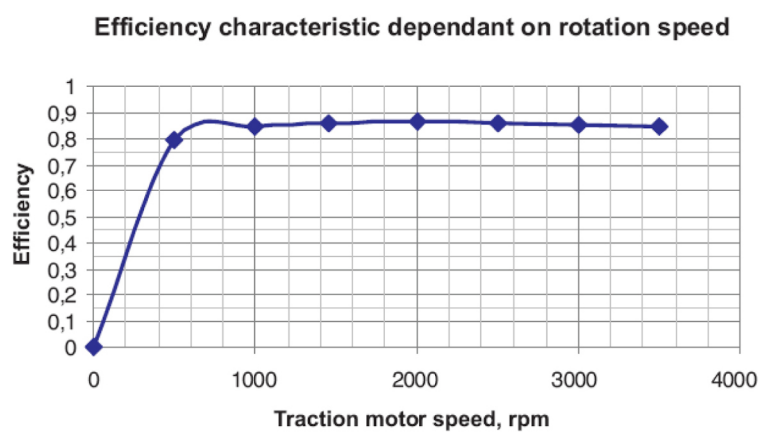


Fig. 7. Total drivetrain efficiency versus rotation speed of the tractor AM



Fig. 8. Information panel located in the driver's cabin