EVALUATION OF THE OPERATIONAL VIABILITY OF THE USE OF ELECTRICITY AS A SOURCE OF POWER IN AGRICULTURAL TRACTORS

Vanderson Rabelo de Paula
Instituto Federal Sul de Minas/IFSULDEMINAS, Departamento de Engenharia Agrícola, Machado, MG, Brazil
Corresponding author: E-mail: Vanderson.paula@ifsuldeminas.edu.br

Carlos Eduardo da Silva Volpato
Universidade Federal de Lavras/UFLA, Departamento de Engenharia/DEG, Lavras, MG, Brazil

Jackson Antônio Barbosa
Universidade Federal de Lavras/UFLA, Departamento de Engenharia/DEG, Lavras, MG, Brazil

Abstract: Economic and environmental problems caused by more than a century of intense use of fuels derived from petroleum have led to a constant search for alternative sources of energy, ether in urban areas or in the agricultural environment. In this context, the aim of this study was to evaluate the operational viability of the use of electricity as an energy source for agricultural tractors. For that, comparison of performance curves between internal combustion engine, used in agricultural tractor, and an electrical motor has been made. The electrical motor performance was considered in the proposal a theoretical set up of an electrical tractor. The hypothesis was evaluated considering its autonomy in different power demands and compared to a conventional farm tractor regarding to operating energy cost and energy efficiency. The electrical motor presented the best results for torque, power, energy efficiency and operational energetic cost. The autonomy of theoretical configuration was superior then eight hours per day, for medium and lower power, working in lower rotations. Considering these results, it was possible to conclude that the use of electricity as an energy source for agricultural tractors is viable in terms of cost and energy efficiency and has potential for intensification of research in this field.

Keywords: Agricultural mechanization; energetic efficiency; alternative energy; sustainability.

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INTRODUCTION

According to Armstrong (2000) agricultural mechanization is the seventh greatest invention of the twentieth century, overcome the computer, phone and spacecraft.

According to Steckel and White (2012), the efficiency of agricultural tractors in mechanized operations has dramatically reduced the necessary inputs in food production. However, according to Serrano (2007), the tractors are selected to supply the needs of implements with high power demand, which often leads to oversize the tractor in relation to implements that require less power.

Volpato et al. (2009) conducted performance tests on a tractor in which observed that as the required traction strength decreased, the tractor passes to an oversized condition and thus, there is a significant increase in specific fuel consumption. According to Silveira and Sierra (2010) for comparative estimates, the energy efficiency using the average specific fuel consumption in liters per kilowatt-hour (kWh L^{-1}), was based on the most frequent sites of use of the tractor engine. Thus, it can be said that in oversized tractors, energy efficiency becomes even lower.

According to Mousazadeh et al. (2010), the energy issue, agricultural tractors have great contribution portion for air pollution. US Environmental Protection Agency (USEPA, 2012) off-road vehicles such as agricultural tractors, are responsible for 15-20% of air pollution in US. Based on economic and environmental problems caused by the massive dependence on fossil fuels is that the automobile industry has been interested in development of vehicles that use alternative sources of energy, such as electric and hybrid vehicles.

Mousazadeh et al. (2010) the government of Barack Obama, in the United States, set a goal of one million electric vehicles circulating in its highways by 2015. A series of patents on electric tractors, as required by Edmond (2006) show that the concern in using renewable energy sources is not limited to road vehicles but also extending to other types of vehicles, such as agricultural tractors.

In this context the aim of this research was to evaluate the operational viability of the use of electricity as a source of power in agricultural tractors, determining and comparing its operating costs with internal combustion engine used in a conventional tractor and determining its operating autonomy for different power demands.

MATERIAL AND METHODS

Dynamometric tests were conducted on an agricultural tractor and an electric motor. The test with the tractor was held at the Technology Center of Machinery and Agricultural Mechanization from the Department of Engineering, Federal University of Lavras. It was used a tractor brand Green Horse Model 205 with an internal combustion engine (ICE) rated power of 14.9 kW at 2300 rpm. A dynamometer was used for tests of power take-off (PTO) model NEB 200, AW Dynamometer and also a volumetric fuel consumption meter, which is a graduated cylinder with solenoid valves that control the input and output flow of fuel which is measured by a level difference with respect to time. The dynamometer allows direct reading of the data of torque, speed and power. If necessary, a data acquisition system can be coupled to it(Figure 1A).

The dynamometric test of the electric motor (EM) was conducted at the Institute of Energy and Environment, University of São Paulo - IEE / USP. For this test was used a three-phase electric motor with a power output of 22 kW, connected in a drive three-phase frequency inverter that allowed change the motor speed.

The conjunct electric motor and frequency inverter (EM-FI) was tested in an electrical dynamometer brake composed by an electric current generator acting as load for the tested engine, submit it to the braking which is dependent on controls and electrical loads installed in the circuit (Figure 1B). To ensure parity between the internal combustion engine (ICE) and the electric motor, the maximum power of the electric motor was limited to 15 kW to maintaining equivalence compared to the ICE.

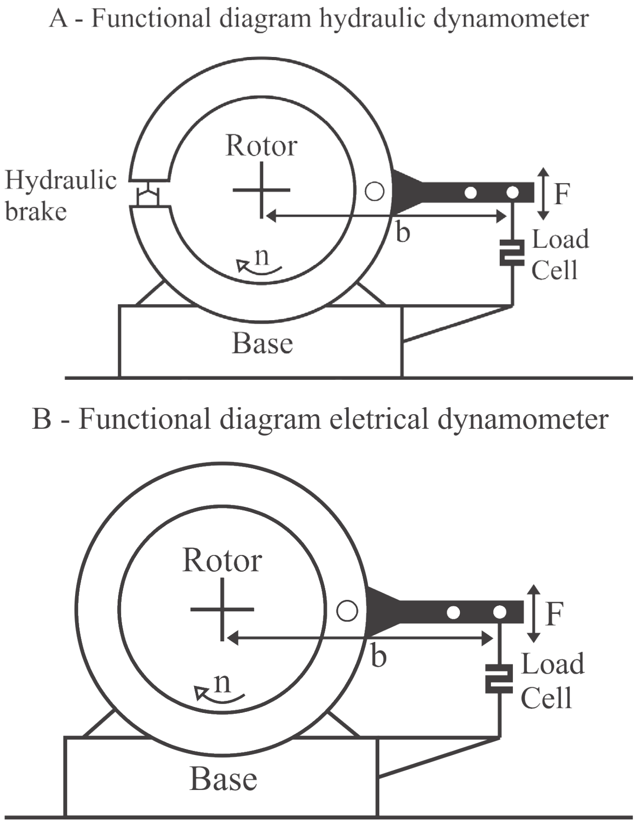

Figure 1: Scheme of a hydraulic dynamometer brake (A) and a electrical dynamometer brake (B).

For the tests in the ICE was adopted the standard NBR 1585/1996 of the Brazilian Association of Technical Standards (ABNT), which applies to the assessment of the internal combustion engine performance. For the tests in the EM- IF was adopted a methodology described by NBR 17094-2 / 2008 of the Brazilian Association of Technical Standards (ABNT), which applies to evaluating the performance of electric induction motors.

The methodology for determining the variables for the ICE and EM-IF was divided into two parts:

First acquisition of the direct variables, which could be obtained in test batteries with three repetitions: power (P), torque (T) and rotation (n) on the dynamometers. The direct variables for the ICE and EM-IF were obtained with the Equations 1 and 2.

$$T = F \times b \tag{1}$$

T - Moment of force or torque (N m)
F - force applied to the load cell (N)
B - dynamometer arm's length lever (m)

$$P = \frac{T \times n}{9,552.54} \tag{2}$$

P - Power (kW)
n - engine rotation (rpm)
9,552.54 - conversion factor

Second step consisted of determination of indirect variables that were torque reserve specific consumption (CS) and thermal efficiency of the ICE (η). The indirect variables of the ICE were calculated by Equations 3, 4 and 5.

$$\Delta T = \frac{(Tm - Tn)}{Tn} \times 100 \tag{3}$$

ΔT - torque reserve (%)
Tm - maximum torque (N m)
Tn – torque at full power (N m)

$$C_S = \frac{\rho \times Chv}{P} \times 1000 \tag{4}$$

C_S - specific fuel consumption (g kW.h^{-1})
ρ - fuel density (kg 1^{-1})
Chv - volumetric consumption (1h^{-1})

$$\eta = \frac{3,600}{C_S \times PCI} \times 100 \tag{5}$$

η - Engine thermal efficiency (%);
PCI - power net calorific value of the fuel (MJ kg-1);
3,600 - constant for unit conversion.

The indirect variables for the tests in the EM-IF were torque reserve, who was calculate with the Equation 3, and electric motor efficiency calculated by Equation 6.

$$\eta_{ME} = \frac{H_{axle}}{H_{abs}} \times 100 \tag{6}$$

η_{ME} - eletric motor efficiency (%)
H_{axle} - mechanic power at axle (kW)
H_{abs} - Eletric power absorbed by electric motor and frequency inversor (EM/FI)

The energetic cost of ICE was defined as the amount in Reais (R$) spent per kWh with produced mechanical energy. For tractor with a diesel engine ICE, the energetic cost can be defined by Equation 7:

$$CE_{ICE} = \frac{C_h \times V_c}{H_r} \tag{7}$$

CE_{ICE} - Energetic cost of internal combustion engine (ICE), (R$ kWh^{-1})
C_h - Fuel consumption schedule, (L h^{-1})
V_c - Price of the fuel (R$ L^{-1})
H_r - Reduced power (kW)

The price of the fuel was obtained by means of the average diesel prices of 24 gas stations in the southern state of Minas Gerais, which reached the average value of R$ 3.02 per liter of fuel between may, 4th and 7th, 2016.

The energetic cost of EE-FI was determined considering an electric vehicle configuration. Thus, the ME-FI set were powered by a battery pack that on the end of each test would be recharged by a charger connected to the mains. Thus, for the calculation of the energetic cost it is necessary to consider the battery charger efficiency. Thus, it was possible to deduce the equation for determining the energetic cost of the set EE (Equation 8).

$$CE_{EM} = \frac{\left(\frac{H_{abs.}}{\eta_{CB}} x V_{EE}\right)}{H_{eixo}} \tag{8}$$

CE_{EM} - energetic cost of electric motor, (R$ kWh^{-1});
H_{abs} - electric power absorbed by the ME-FIset, (kW);
η_{CB} - battery charger efficiency;
V_{EE} - price of electricity, (R$ kWh^{-1});
H_{eixo} - mechanical power in the electric engine axle (kW)

The price of electricity used in the calculation of the energy cost of the EE-FI set was obtained through a table electricity rates in rural areas made available by the National Electric Energy Agency (ANEEL, 2014) of Brazil. It was used the price charged by the energy company of Minas Gerais (Cemig), which was R$ 0.347 per kWh.

On the basis of performance of the EE-FI set, was proposed a theoretical configuration of agricultural tractor powered by electricity and characterized only as traction machine (Figure 2).

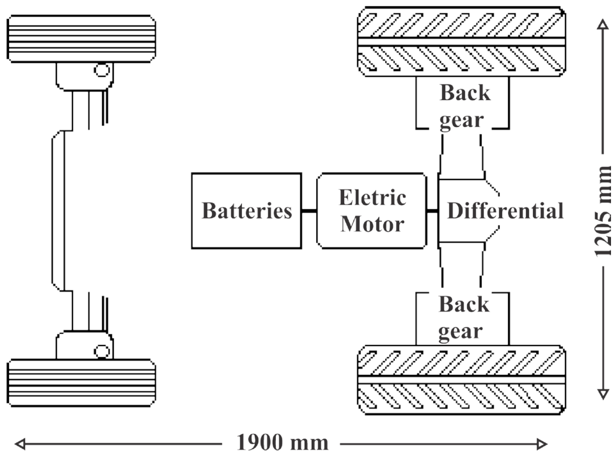

Figure 2: Diagram of theoretical configuration of the electric tractor.

The entire mass of the tractor conventional components that are unnecessary in the electric tractor model was converted into mass batteries. The purpose of this action was to keep the weight/power ratio of the tractor and to maximize their autonomy.

The mass of the ballasts of the tractor was also converted in batteries mass. Thus, in operations of higher demand for power, the mass of the batteries would be increased, resulting in weight gain. This is necessary for operations that require higher power demand. In this case also occurs autonomy gain.

As the total mass of the vehicle was calculated, a model could be defined as the number of batteries to be used. This decision was because the lithium battery has the highest energy density and power (FISHER et al. 2012) The battery adopted for the simulation presents a 48V voltage, rated current discharge 30Ah and mass 18kg. Defined the number of batteries, it was possible to calculate the electrical power available to the tractor by means of Equation 9:

$$HE_T = N_B \times V_B \times C_B \tag{9}$$

HE_T – Electric Power available on the tractor, (W);
N_B - number of batteries;
V_B- battery of voltage, (V);
C_B - battery specific capacity, (Ah).

The components used in electric tractor theoretical configuration, were defined a virtual prototype with all the considered components could be developed in order to verify some weight characteristics of the tractor as the location of its center of gravity and the weight distribution on the axles. For this, we used the CAD software (Computer-Aided Design) SolidWorks (2013).

The autonomy of the electric tractor prototype for different demands of mechanical power was calculated using a model that estimates the battery discharge time. This model is defined by Porciuncula et al. (2012) and is based on the law of Peukert, considering nonlinear properties to discharge a lithium ion (Equation 10)

$$A_{CTTE} = \frac{N_B \times \left(\frac{21787630,16}{\left(H_{abs} \times 270,27\right)^{1,0195}} \right)}{60} \tag{10}$$

A_{CTTE} - autonomy of the electric tractor theoretical configuration, (h);
N_B – number of batteries;
H_{abs}- electric power absorbed by the set- EM-FI, (W).

To calculate the autonomy of theoretical configuration of farm tractors in different power demands, the set EM-FI was subjected to dynamometric testing at full load (100%) and three partial loads 25, 50 and 75% of maximum power.

RESULTS AND DISCUSSION

In Figure 3, shows the torque values and power of ICE and the set EM-FI. The rotation values were defined according to their rotations obtained from the EM-IF set operating at frequencies of 30, 45, 60 and 75 Hz. For these four operating frequencies, the set EM-FI was operated at 880 rpm, 1300, 1800 and 2350 rpm, respectively. For ICE was added a fifth rotation of 2500 rpm, corresponding to the maximum motor rotation.

It could be seen that the EM-FI had set torque and power values higher than those presented by ICE across the rotation range where the two was operated machines.

The torque the set EM-FI was 36.2% higher than the ICE in the less difference between the two and 45.7% higher than in most difference shown in rotation 2300 rpm. Under these conditions, the torque values provided by the set EM-FI enable its adoption in an agricultural tractor with the characteristics of the tested model. Regarding the power the least difference in rotation was 1300 rpm, where the power of the set EM-FI was 1.53% greater than the power of the ICE. The biggest difference was 15.89% in speed of 1800 rpm.

The power values presented by the EM-FI exceed in relation to its use as a power source to the tractor used. Rodrigues et al. (2006) comparing electric motors and internal combustion engines as power sources for a tractor, achieved better results with electric motors, even with those having a 15% lower power.

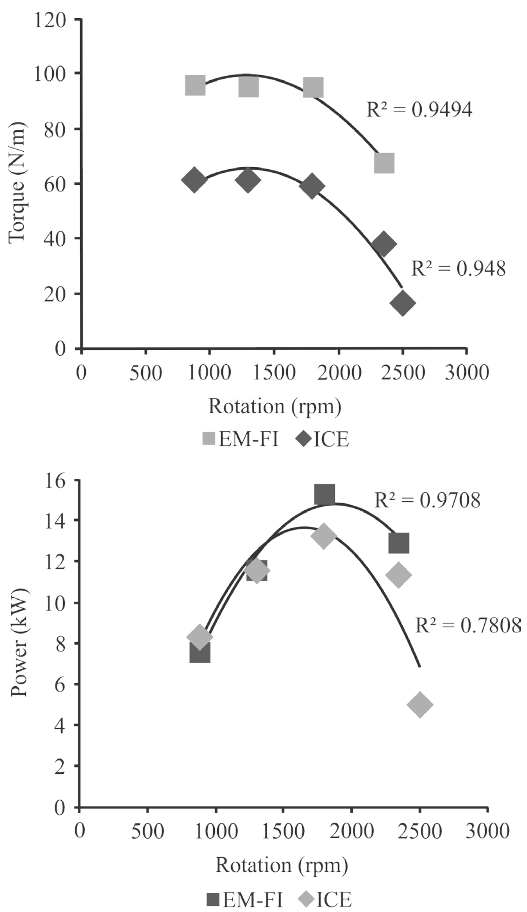

Figure 3: Curves of torque and power drawn from the results obtained in dynamometric testing of the tractor equipped with ICE and EM-FI.

The curves of efficiency and energy cost for the two engines are shown in Figure 4. The set EM-FI showed the efficiency values much higher than the figure provided by ICE throughout the rotation range. The values obtained for the set EM-FI match those supplied by the manufacturer and are also in accordance with Fedrizzi et al. (2011) who vouched that electric motors in general, frequently have efficiencies higher than 80%. The energy efficiency for ICE was 35.83% in rotation of 1800 rpm.

The ICE efficiency values are in agreement with the values observed by Barbosa et al. (2008) when testing a tractor of the 58,2kW power in one dynamometer power take-off (PTO), achieved a maximum efficiency of 38.36%. The efficiency values obtained for ICE are greater than those described by the Department of Energy of the United States - USDE (2012), according to which, considering the loss of accessories, energy efficiency diesel engine is only 18.4 %.

The EM-FI had the lowest results of cost throughout the rotation range analyzed, which reinforces the viability of the adoption of electric motors as a source of power in agricultural tractors. In addition, energy costs EM-FI showed a decreasing trend in so far as rotation is increased, unlike the ICE who presented a significant cost increase as the rotation increased.

Energy costs for the two motors can be explained by observing their energy efficiencies. While the EM-FI efficiency remained nearly constant, the efficiency of the ICE significantly changed with variation of the rotation, causing the same behavior in the cost. This common behavior of an ICE makes compulsory the use of a large number of gears in tractors, so that they can offer variation of the power and speed needed o the different agricultural operations while maintaining the ICE in the rotation range of the better energy efficiency. According Mialhe (1996), this rotation is called the motor operation range, and is situated between the maximum torque and the rotational of maximum power.

The low cost of the energetic values in the EM-FI enables its use throughout the rotation range allowing the use of a simpler mechanism of transmission of lower mass and lower cost.

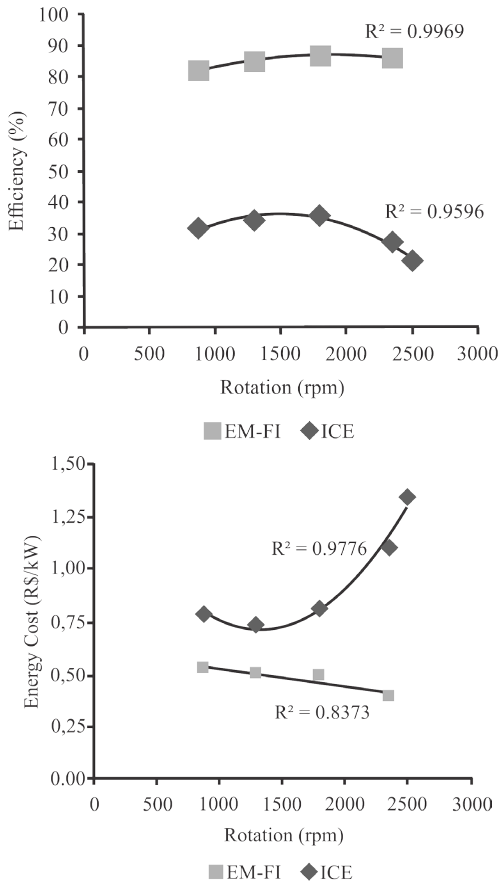

Figure 4: Curves of efficiency and energy cost drawn from the results obtained in dynamometric testing of the tractor equipped with ICE and the set EE-FI.

In Table 1 the necessary changes to the tractor to become an electric vehicle are described. These changes resulted in a reduction of 695 kg in the total mass of the vehicle and the mass was restored in the form of batteries. This value would allow the installation of 38 batteries totaling an installed power of 54.72 kW.

Table 2 shown the results of the weight/power relation of the theoretical configuration of electric tractor compared to conventional tractor. The weight/power relation in this electric tractor theoretical configuration was 86.6 kgf kW^{-1}, and is 0.8% lower than the power/weight relation of conventional tractor used in this work.

Values of weight/power ratio of this magnitude were found in tractors with power less than 40 kW by Schlosser et al. (2005) when comparing the weight / power ratio of 106 national tractors (Brazilian tractors).

The weight distribution on the axis of theoretical configuration are was 68% on the rear axle and 32% on the front axle. This distribution is deemed appropriate for 4x2 tractors according Mialhe (1996) and was obtained by adapting the distribution of the batteryes in tractor structure shown in Figure 5.

The values obtained with 25, 50, 75 and 100% of the power EM-FI necessary for the estimate of the autonomy of electric tractor theoretical configuration submitted to different power demands are shown in Table 3. The absorbed electric power and energy efficiency could also be observed.

Table 1: Mass of conventional tractor components replaced by the mass of batteries in electric tractor theoretical configuration.

Conventional Tractor	Mass of conventional tractor component (kg)	Electric tractor	Mass of electric tractor component (kg)	Mass changed for batteries
ICE and acessories	315(1)	ME-IF	140(1)	175
gearbox	140(2)	unnecessary	0	140
Solid ballast	210(1)	Batteries weight used as ballasts	0	210
Liquid ballast (water in tires) (75%)	130(1)	Batteries weight used as ballasts	0	130
Automotive Battery	40(1)	unnecessary	0	40
Total mass of batteries (kg)				695

Table 2: Comparison of weight characteristics of the theoretical electric tractor with conventional tractor.

Characteristic	Electric tractor theoretical configuration	Conventional tractor
Weight/power relation - kgf kW^{-1} (kgf CV^{-1})	86.6 (63.6)	87.3 (64.1)
Weight in rear axle (%)	68	66
Weight in front axle (%)	32	34

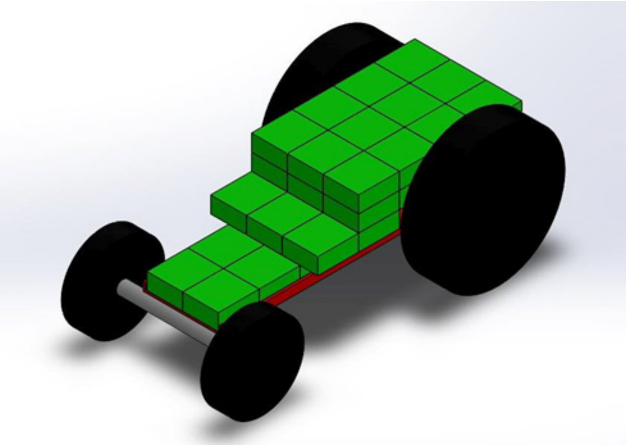

Figure 5: Simulation of weight distribution on the axis of the electric tractor theoretical configuration.

Table 3: mechanical power values, absorbed electrical power and energy efficiency obtained in the dynamometer tests with four different power levels of the set EE-IF.

Mechanic Power(kW)				
Rotation (rpm)	25%	50%	75%	100%
880	2.23	3.33	5.53	7.61
1300	3.31	5.04	8.26	11.6
1800	4.47	6.66	11.0	15.3
2300	4.74	7.41	10.2	12.9
Absorbed Electric Power (kW)				
Rotation (rpm)	25%	50%	75%	100%
880	3.24	4.40	6.88	9.29
1300	4.63	6.42	9.91	13.60
1800	5.99	8.29	12.90	17.60
2300	6.18	9.00	12.00	18.00
Energy efficiency (%)				
Rotation (rpm)	25%	50%	75%	100%
880	68.83	75.68	80.38	81.91
1300	71.49	78.50	83.35	85.29
1800	74.62	80.34	85.27	86.93
2300	76.70	82.33	85.00	71.67

Even in the most unfavorable condition with the underutilized engine with only 25% of the power the minimum energy efficiency was 68.83%. which is 100% higher than the best energy efficiency presented by ICE in tests previously.

The autonomy and power curves for different power percentage are shown in Figure 6. The set EE-FI operated of four different frequencies of 30. 45. 60 and 75 Hz. It has been conditioned to the desired power values for the four curves which were obtained at a nominal operating frequency to the set of the 60 Hz corresponding to the rotation of 1800 rpm. In this rotation range observed that curve 25% of the presented power the actual value of 29.2% of maximum power. In 50% range the real value was 43.5% of maximum power and in the range of 75% the actual value observed was 71.89% of maximum power.

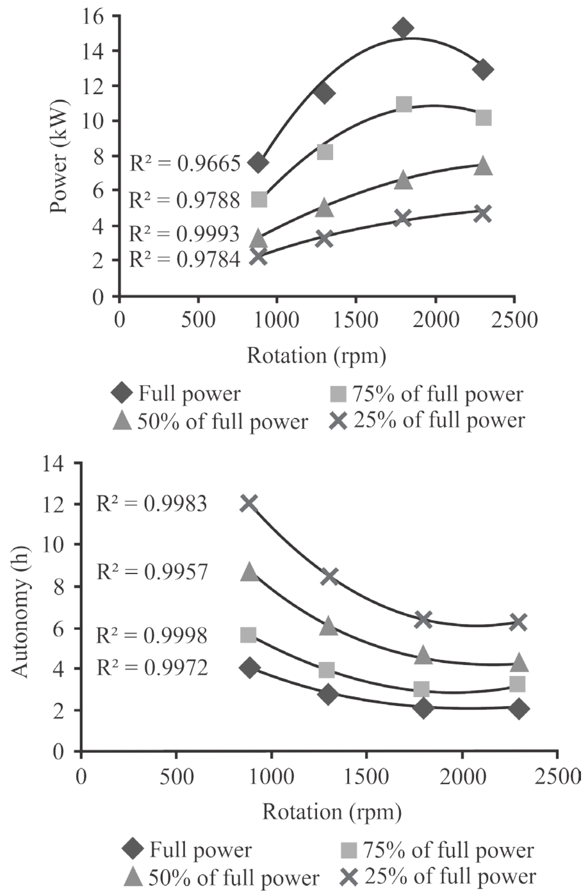

Figure 6: Power Curves and autonomy drawn from the results obtained in dynamometer testing of the set EM-FI.

The autonomy time for the power range of 25% was higher than a conventional working day of 8 hours working on rotations up to 1300 rpm. Naturally. as the power is increased. the time range reduces. At 100% power. the best autonomy time was for the rotation of 880 rpm with 4.12 h while the worst time was 2.1 h for the rotation of 2300 rpm.

Despite the low range of values presented for major power groups. these results were obtained considering that the engine was constantly subjected to high power ranges.

which in usual agricultural practice operations, it does not. Its necessary to consider the maneuver times where the defendant engine power is minimal. requiring only the displacement of the tractor-machine assembly or tractor-implement.

In addition to time maneuver which lead to a reduction in discharge velocity it is necessary to consider the different demands of power in which a tractor is submitted the according to the different agricultural operations and also the power variations that occur during the same transaction. Mialhe (1996) reported that tractors under field conditions are not requested in with more than 85 to 90% of its maximum power.

To Silveira and Sierra (2010) tractors with power of less than 30 hp work only 29.43% of the time in traction operations at speeds below 8 km h-1. which require high power. So in 70.57% of the times. tractors with power up to 30 hp. work an average of operations and low power demand and in those conditions the autonomy time would be enough for a typical working day of 8 hours.

Gamero and Benez (2009) evaluating the performance of a subsoiler to different speeds and depths found variations of up to 103.7% between the maximum and average power on the draw bar showing that even in high demand for power operations such as subsoiling. the average power demanded is less than the maximum engine power.

CONCLUSIONS

The set electric engine/frequency inverter EE-FI provides the best cost results. energy efficiency. torque and power as compared to the internal combustion engine ICE of a conventional tractor.

The electric tractor theoretical configuration presented results of autonomy to ensure operational viability. for medium power demands with lower engine speed levels. For high demand for the power. autonomy time was less than one working day of eight hours.

The results indicate great potential for the future use of electricity in the drive tractors with the evaluation of new technologies for electrical energy storage and construction of functional physical prototypes.

REFERENCES

ARMSTRONG, N. A. **The Engineered Century**. National Press Club. February 22, 2000 Available in: http://www.greatachievements.org/Object.File/Master/4/254/na_speech.pdf. Access in: September. 13. 2014.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 1585: veículos rodoviários**: código de ensaio de motores: potência líquida efetiva. Rio de Janeiro. 1996. 26 p.

BARBOSA, R. L. et al. Desempenho Comparativo de um Motor de Ciclo Diesel Utilizando Diesel e Misturas de Biodiesel. **Ciência e Agrotecnologia**, 32(5): 1588-1593, 2008.

BRASIL. Agência Nacional de Energia Elétrica. **Tarifas**: consumidores finais. Disponível em: Available in: <http://www.aneel.gov.br/area.cfm?idArea=91&idPerfil=5>. Access in: January. 12. 2014.

EDMOND, B. W. **Multifunction electric tractor**. US Patent n. EP1645456 A2. 23 Mar. 2006. Available in: http://www.google.com/patents/EP1645456A2?cl=en. Access in: January 14. 2013.

FEDRIZZI, M. C.; ALMEIDA, M. P.; MELENDEZ, T. A. Desempenho operacional de motobomba vibratória para pequenos sistemas fotovoltaicos. **Avances en Energías Renovables y Medio Ambiente**, 15(4): 13-19, 2011.

FISHER, P. et al. Electronic integration of fuel cell and battery system in novel hybrid vehicle. **Journal of Power Sources**, 220(1): 114-121, 2012

GAMERO, A. C.; BENEZ, S. H. Resultados operacionais de um subsolador com curvatura lateral ("Paraplow") em função da velocidade e profundidade de trabalho. **Revista Energia na Agricultura**, Botucatu. 24(1): 1-16, 2009.

MIALHE, L. G. **Máquinas agrícolas**: ensaios & certificações. Piracicaba: CNPq-PADCT/TIB-FEALQ. 1996. 722p.

MOUSAZADEH, H. et al. Life-cycle assessment of a Solar Assist Plug-in Hybrid electric Tractor (SAPHT) in comparison with a conventional tractor. **Energy Conversion and Management**, 52(2011): 1700-1710, 2010.

PORCIUNCULA, C. et al. Avaliação comparativa entre o modelo elétrico Battery e os modelos analíticos Linear e Lei de Peukert. **Revista Brasileira de Computação Aplicada**, 4(1): 71-80, 2012.

RODRIGUES, D. E. et al. Micro trator agrícola adaptado com diferentes alternativas energéticas no revolvimento de café em terreiro. **Revista Ciências Técnicas Agropecuárias**, 15(4): 8-15, 2006.

SERRANO, J. M. P. Desempenho de tratores agrícolas em tração. **Revista Pesquisa Agropecuária Brasileira**, Brasília. 42(7): 1021-1027, 2007.

SILVEIRA, G. M.; SIERRA, J. G. Eficiência energética de tratores agrícolas fabricados no Brasil. **Revista Brasileira de Engenharia Agrícola e Ambiental**, 14(4): 418–424, 2010.

SCHLOSSER, J. F. et al. Análise comparativa do peso específico dos tratores agrícolas fabricados no Brasil e seus efeitos sobre a seleção e uso. **Ciência Rural**, 35(1): 92-97, 2005.

SOLIDWORKSCORPORATION. **Solidworks**. Concord. 2013. Software.

STECKEL, R. H.; WHITE, W. J. "**Engines of Growth**: Farm Tractors and Twentieth-Century U.S. Economic Welfare." NBER Working Paper 17879. Massachusetts. March 2012.

UNITED STATES DEPARTMENT OF ENERGY. **Fuel economy**. Disponível em: <http://www.fueleconomy.gov/featv.shtml>. Acesso em: 12 fev. 2012.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. **Office of Mobile Sources**. Non-road engines and air pollution. Available in: <http://www.epa.gov/OMS/consumer/20-nonrd.pdf>. access in: June 22. 2012.

VOLPATO, C. E. S. et al. Desempenho de Motor Ciclo Diesel Alimentado com Biodiesel de Soja (B100). **Ciência e agrotecnologia**, Lavras. 33(4): 1125-1130, 2009.