# Electric-Motion in Romania - Overview
## *Study on Machining Parameters of EV Charging Station Mechanical Components*

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Abstract: This paper presents some relevant aspects of charging infrastructure for electric vehicles in Romania. It evidences the charging station and fast charging stations designed and installed by the first Romanian company dedicated 100% to e-mobility, E-Motion Electric. Also, a study on machining (milling) parameters of some mechanical components of electric vehicle (EV) charging station is done and, finally, the regression model for these parameters is determined. This model would be further used for machining process optimization.

# 1 INTRODUCTION

Ecological technologies (Eco-Technologies) include the technologies which does not harm the environment so hard, when compared to traditional similar technologies applied to obtain the products required by the same human need (http://www.insee.fr/en/ecotechnologies.htm, 2015).

Energy efficiency is "using less energy to provide the same service" and it is not energy conservation (http://eetd.lbl.gov/ee/ee-1.html, 2015). Most of the times, the energy efficiency can be quatified by comparing the specific energy consumption for obtaining, in the same condition, the product, service or, process required. By reducing these consumptions, wihtout affecting their quality, represents the increase on energy efficiency (http://www.utgjiu.ro/revista/ing/pdf/2009-03/35_ALINA_DANIELA_HANDRA.pdf, 2015).

The concept of energy efficiency, or optimization of electric energy consumption has become an essential challenge worldwide, nowadays. In fact, saving energy does represent the cheapest energy resource, easy to produce and environmental friendly.

One solution, with highly positive impact on the environment, is represented by the focus on electric vehicles (EV). These vehicles have to be charged and, further, driven, so that to use their required energy in an effiecient way, as well as an environmental friendly one. The chargeable electric vehicles, hybrid ones included, have become more and more popluar, for person transportation (electric train, electric bus, electric car, electric bike). There are obvious advatages, such as: no $CO_2$ emission, travel comfort, technology friendly over the environment, low expenses (http://birdie-electriccar.eu/ro/transport-de-persoane, 2015).

Based on the asepects mentioned above, it is estimated a, relatively, high need for good charging infrastructure for electric vehicles in Romania

# 2 CONTEXT AND OVERVIEW

In the past 50 years, Europe has changed a lot - just like the rest of the world. Nowadays, more than ever, in a constantly evolving world, Europe must face new challenges. Economy globalisation, demographic evolution, climate changes, the need for long-lasting energy sources and modern security threats are the main challenges of the XXI$^{st}$ century.

## 2.1 Context

National and international relationship of Romania, member of European Union and the focus on sustainable development, including friendly environmental technologies, lead to the increasing importance of ecological technologies with high energy efficiency for new generation of vehicles,



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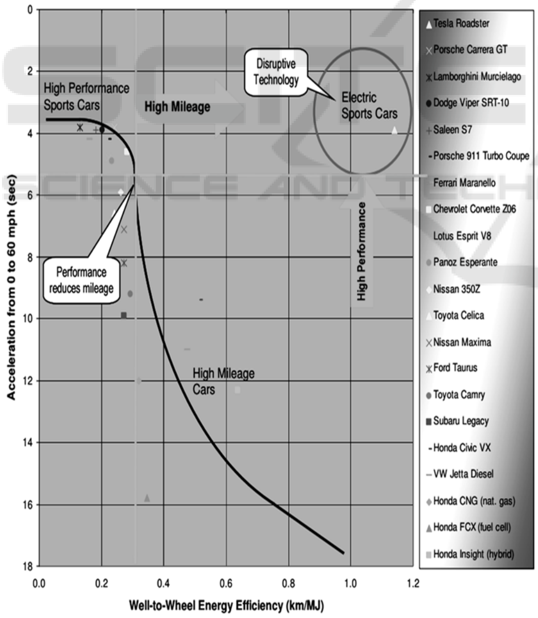
specially envisaging electric vehicles, more specifically, electric cars.

Environment degradation because of industrial development which has mostly been accomplished in a chaotic way, as well as the consequent hunger of resources, exhaustion of fossil fuels: oil, gas, coal are the reason for efficient use of natural resources and for integrated solution of protection and preservation of the environment (http://e-motionelectric.ro/sites/default/files/cataloage/Catalog%20general%20produse.pdf, 2015).

Electric vehicles are sometimes „accused" that they do pollute „somwhere else", because their required energy for battery charging is obtained using industrial porcedures that pollute. But, if there were considered all the emissions, from oil extraction, it would result that the electric vehicle is significantly more efficient and pollutes less than any other options – see figure 1.

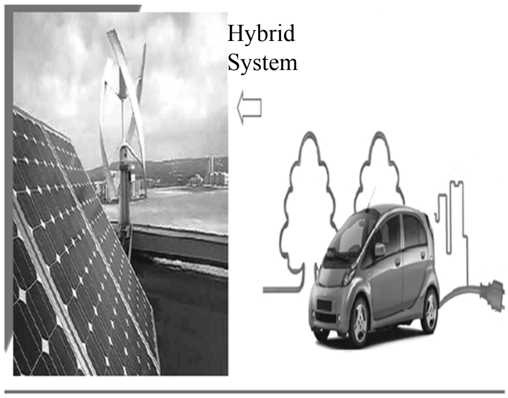
One relevant situation is that where the charging stations (E-Motion Street Box) are situated in isolated areas, with no plugin sources to the electricity distribution network. These stations will be connected to renewable energy sources so that, the electric vehicle charging is 100% green, non-pollutiing – see figure 2.




(http://www.evworld.com/library/Tesla_21centuryEV.pdf)

Figure 1: The highest energy efficiency is that of electric vehicle.

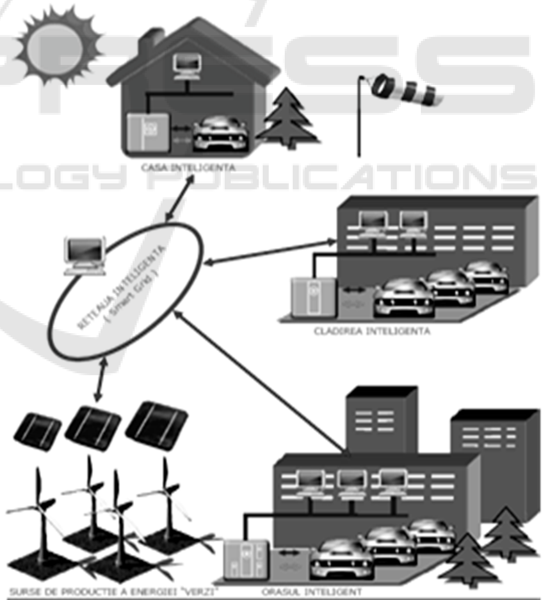
In the context of climate changes and of cities that turn into sustainable smart cities, high attention is given to the systems for monitor, analysis and adjustment to envrionmental changes, energetic managemnt, etc. The electric transportation and its charging infrastructure represents components of the smart grid of the future, so that further development of the electric vehicles charging stations smart grid is really important – see figure 3.




(http://e-motionelectric.ro/)

Figure 2: Eco-tehnology for charging the electric vehicle.

This smart grid enables route optimization depending on the emplacement and performances of existing charging stations, correlated to roads status and traffic situations / emergencies.




(http://e-motionelectric.ro/)

Figure 3: Urban transportaton and its infrastructure – components of the smart city.

## 2.2 Overview

E-Motion Electric is the first Romanian company dedicated 100% to e-mobility, as producer for electric vehicle charging stations. It also offers the knowledge in developing the best solutions for charging infrastructure in Romania and e-mobility solutions in,general.

In 2011 it was installed the first public charging station in Romania. It has 1 plug 230V and 16A; controlled acces with RFID; energy meter and is designed for semi-public use

This EV charging stations meet the IEC standards and charge the vehicles in mode1, 2 and 3, on Schuko type 1 or, type 2 plugs. There are also implemented payment systems with both credit card or prepaied

(http://e-motionelectric.ro/)

Figure 4: Exterior semi-public charging station.


(http://e-motionelectric.ro/)

Figure 5: Interior private charging station.


(http://e-motionelectric.ro/)

Figure 6: Exterior semi-public fast charging station.

One of the exterior semi-public charging station designed and installed in Romania is presented in figure 4. It is type 1, with 1 plug 230 V and 32 A; controlled acces with RFID; energy meter and designed for semi-public use.

One of the interior private charging stations designed and installed by the compnay in Romania is shown in figure 5. It has 1 plug 230 V and 16 A and energy meter.

The first fast charging station designed and installed in Romania in 2014, for exterior semi-public use, is evidenced in figure 6. It has 1 plug 230 V and 16 A, 3,6 kW; Type 2 plug 400 V and 32 A, 22 kW.

In 2013, in Romania, it was installed only 1 (one) pulblic charging station. In 2014, in Bucharest (capital of Romania) there were 9 (nine) public charging stations – see figure 7.

The European Comission announced that soon, there will be rules regarding the development of public charging station infrastructure for electric vehicles. For Romania, the Comission estimated an amount of 10,000 charging stations to be installed by the year 2020.

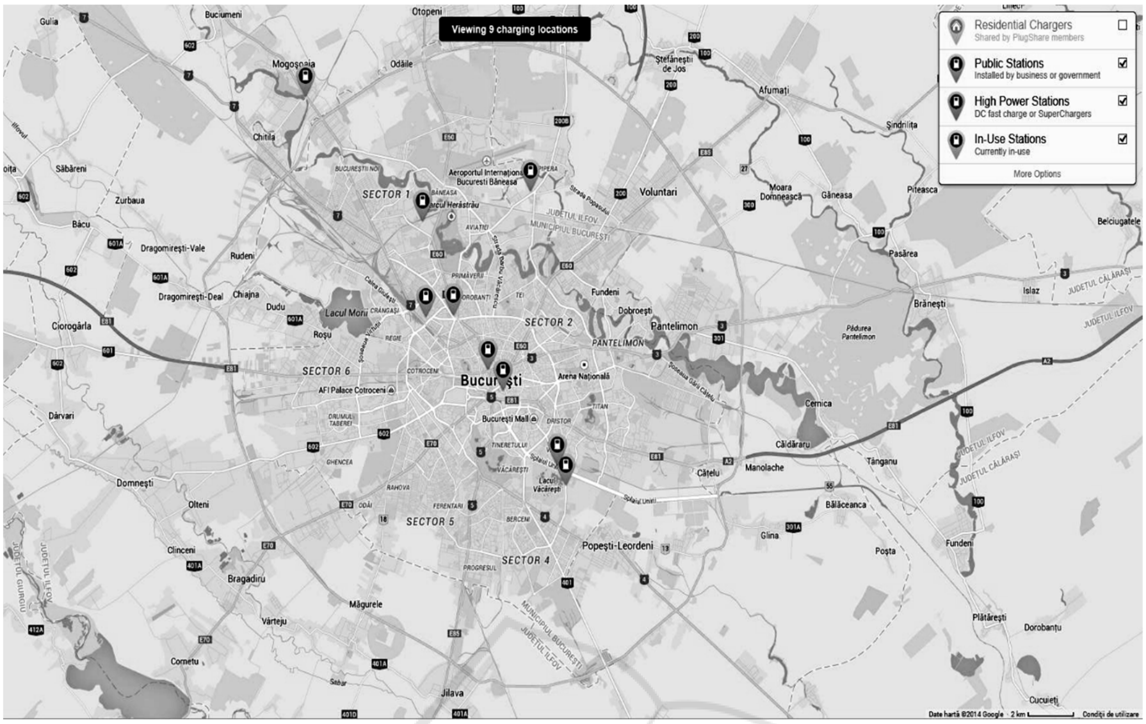



Figure 7: Public charging stations location in Bucharest district, 2014.



# 3 STUDY ON MACHINING PROCESS PARAMETERS

All the above mentioned do evidence the importance of developing the infrastructure of charging stations for electric vehicles in Romania. Each of these stations has a mechanical part – more specifically the “frame” sustaining all the components for automation.

In figure 6, one can notice the support – front case of the fast charging station. It is made of composite material, machined by milling process so that to obtain the prescribed (designed) geometrical precision parameters: dimensions, tolerances, surface roughness.

The parameters values of the milling process for obtaining parts’ dimensions are estimated not to have optimum values, as the milling tool does not last long. In fact, many times, the tool breaks while machining the contour. That is why, it has been considered of benefit a study on milling process parameters, so that to improve cutting tool (milling) durability.

## 3.1 Research Method

The study on milling process parameters is done so that to finally obtain a regression model enabling the determination of their optimum values for the process. There are some specific steps for this study.

The first step involves “definition” of material to be machined. So, it is: 3 m thick sheet made of composite polymer, PLEXIGLASS (polymethyl methacrylate, PMMA). The second step is that of defining the machining equipment. It is an Isel CNC Router (https://www.isel.com/iselcom_en/, 2015) and the cutting tool is flat end mill, Sandvik Coromant. The third step refer to the variables studied, inputs and output, as well as to the desired type of mathematical relationship – regression model.

The regression analysis is based on design of experiments statistical method and, further, on computer data processing. So, the experiments design is Central Composite Design (CCD) type (Schmidt, 2005) and the applied software is DOE KISS that enable polynomial regression analysis, optimization, plotting 2D and 3D, Pareto diagram, Means Plot etc.

Based on preliminary research and previous work (Iliescu, 2010), as well as on the experience and results obtained in practice, the authors have considered fit the choice of two independent variables (inputs): cutting speed, v (peripheral speed of the cutting tool) and radial depth (of the cut), $a_r$,. The speed values were measured in [m/min] and the depth values were measured in [mm]. The dependent variable considered, due to the interest of this study, was the tangential cutting force component, $F_y$. Other milling process parameters were set to: 1200 [mm/min] for the feed speed, $v_f$; 3 [mm] for axial the depth, $a_a$ and cutting fluid (coolant and lubricant).

## 3.2 Experiments and Data Processing

Experiments were done at the Production Department of E-Motion Electric Company – see figure 8. For measuring milling forces' components, along each of the OX, OY and Oz axes, it was used a dynamometric system with 6 resistive transducers positioned along each axis and connected in a complete Wheastone electronic bridge; a 6 channels tension bridge and a data acquisition system, with DAQPad-6020E type data acquisition component; according to the experimental program applied, each experience was repeated 5 times.

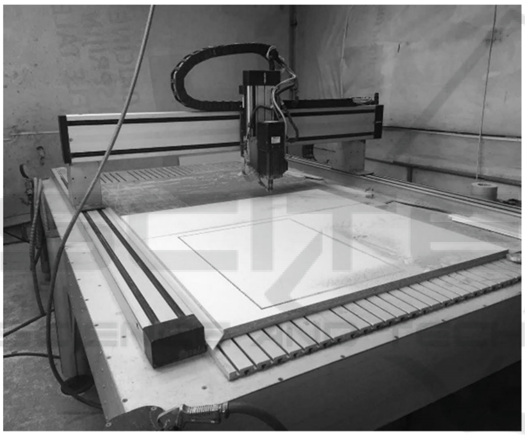


Figure 8: Cylindrical face milling experiments.

The independent variables, are conventionally named $z_j$. Coding their values, results in, $x_j$. Their relationship is expressed by equation (1).

$$x_j = \frac{z_j - \dfrac{z_{\min} + z_{\max}}{2}}{\dfrac{z_{\max} - z_{\min}}{2}} \tag{1}$$

Where: $z_{min}$ is the minimum value of the variable;
$z_{max}$ - the maximum value of the variable.

For this study, the inputs values are the ones mentioned in relation (2) and relation (3):

$$z_1 = v;\ \ v_{min} = 150 \text{ m/min};\ \ v_{max} = 450 \text{ m/min} \tag{2}$$

$$z_2 = a_r;\ \ a_{rmin} = 4 \text{ mm};\ \ a_{rmax} = 8 \text{ mm} \tag{3}$$

The obtained results for the tangential cutting force, $F_y$, as arithmetic mean values, are presented in Table 1. Results of the DOE KISS regression analysis are shown in Figure 9.

Table 1: Experimental results.

| | v [m/min] | | $a_r$ [mm] | | $F_y$ [daN] |
|---|---|---|---|---|---|
| | Real value | Coded value | Real value | Coded value | |
| 1 | 150 | -1 | 4 | -1 | 26.16 |
| 2 | 150 | -1 | 8 | +1 | 33.85 |
| 3 | 450 | +1 | 4 | -1 | 23.60 |
| 4 | 450 | +1 | 8 | +1 | 28.36 |
| 5 | 300 | 0 | 6 | 0 | 26.50 |
| 6 | 300 | 0 | 6 | 0 | 26.42 |
| 7 | 150 | -1 | 6 | 0 | 26.58 |
| 8 | 450 | +1 | 6 | 0 | 25.82 |
| 9 | 300 | 0 | 4 | -1 | 23.28 |
| 10 | 300 | 0 | 8 | +1 | 28.80 |

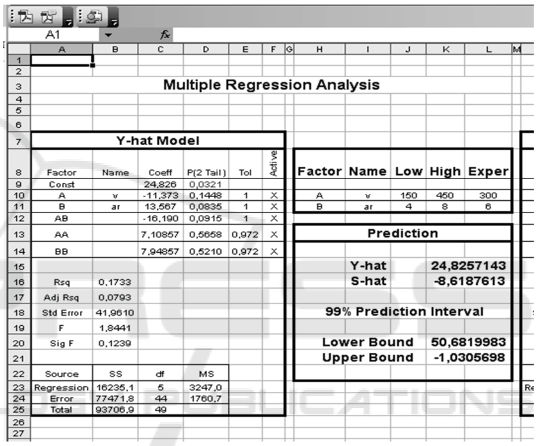



Figure 9: DOE KISS regression analysis results.

Based on regression analysis results, and further processing data – by neglecting the factors that do not have significant influence on the output values, there was obtained the regression model for milling process parameters interaction.

The regression model for coded variables, $x_j$, is given by equation (4).

$$y = 24.826 - 11.373 \cdot x_1 + 13.567 \cdot x_2 - \\ -16.190 \cdot x_1 \cdot x_2 \tag{4}$$

Considering the variables' values considered for this study, relation (1) turns into relation (5).

$$x_1 = \frac{v - 300}{150};\qquad x_2 = \frac{a_r - 6}{2} \tag{5}$$

So, based on all the above, there is obtained the regression model for real variables, $z_j$, expressed by equation (6).

$$F_y = -90.269 + 0.248 \cdot v + 22.974 \cdot a_r - \\ - 0.054 \cdot v \cdot a_r \quad (6)$$

DOE KISS software enables the plot of Pareto charts of coefficients – see figure 10. This charts points out how strong the influence of each input, as well as of inputs interactions, is on the output values.

Also, the software enables the use of Expert optimizer, so that to optimize (minimize for this study) the values of the output (tangential cutting force component, $F_y$) – see figure 11.

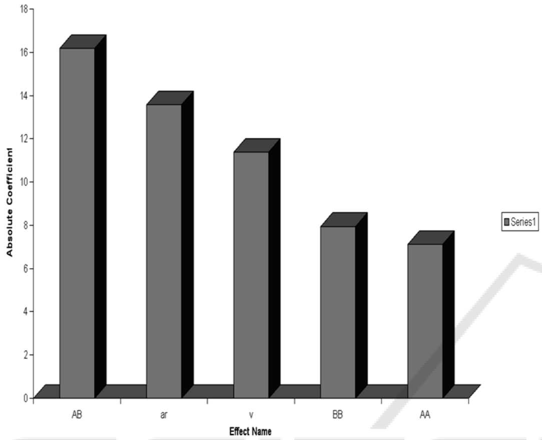



Figure 10: Pareto chart of coefficients.

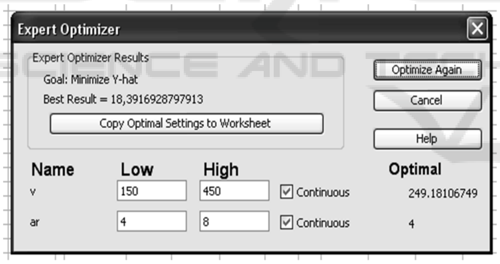



Figure 11: Expert optimizer.

## 4 CONCLUSIONS

This paper was aimed to present aspects of the development of charging station infrastructure for electric vehicles, in Romania.

Due to importance and need for this development, high attention was given to the machining process (milling) of the mechanical parts components of the charging station. Parameters values of the milling process for obtaining parts' dimensions were estimated not to have optimum values, as the milling tool does not last long.

Regression analysis results showed that the radial depth, $a_r$, variable influences the values of tangential cutting force component, $F_y$, while the cutting speed, v, does not significantly influence these values. There is also, the influence of inputs interaction on the output, that should be given attention to. Finally, the regression model would be further used for machining process optimization.

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