CONTRIBUTIONS REGARDING THE STUDY OF TRANSIENT REGIME OF ELECTRIC MOTORS WITH SHORT MOBILE COIL

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REZUMAT. In acest articol este studiat regimul tranzitoriu a două motoare electric cu bobină mobilă în scurtcircuit, alimentate în curent alternativ. Autorii prezintă contribuţiile proprii referitoare la conceperea, realizarea şi testarea de standuri experimentaleale unor motoare electrice cu bobinî mobilă în scurtcircuit şi la identificarea modelului matematic, a parametrilor funcţiei indiciale şi a coeficienţilor ecauţiei matematice a acestor motoare. La final, sunt prezentate concluziile autorilor cu privire la rezultatele studiilor experimentale şi la comportament motorului cu bobină mobilă în regim tranzitoriu.

Cuvinte cheie: motor electric cu bobină mobilă în scurtcircuit, regim tranzitoriu, funcţie indicială.

ABSTRACT. In this paper it is studied the transient regime of two electric motors with short mobile coil, powered in a.c. The authors presents their contributions related to the conception, realisation and testing of a experimental stands for studying the transient regime of an electric motors with short mobile coil and those related to the identification of mathematical model, indexical parameters and mathematical coefficients of this motors. Finally, there are presented the conclusions of the authors as a result on experimental study related to the behaviour of the motor in transient regime.

Keywords: electric motor with short mobile coil, transient regime, indexical function.

1. INTRODUCTION

If in automatic system research is using differential equation subject to adjustment object, the approximate values of the coefficients can be determined by experimental dynamic characteristics of the object: indexical function or transfer function. The form of experimental characteristic usually allows to appreciate the necessary degree and character of the equation.

If indexical function is exponential or close to this curve, that industrial objects may be considered as first degree static objects. In these cases, transient processes are described by differential equations in the form:

$$a_1 x_e'(t) + a_0 x_e(t) = x_m(t). \quad (1)$$

Indexical function of an object is a curve in S, usually such an object can be considered with a certain degree of approximation, as a static object in the second degree.

In these cases the differential equation of the object is:

$$a_2 x_e''(t) + a_1 x_e'(t) + a_0 x_e(t) = x_m(t). \quad (2)$$

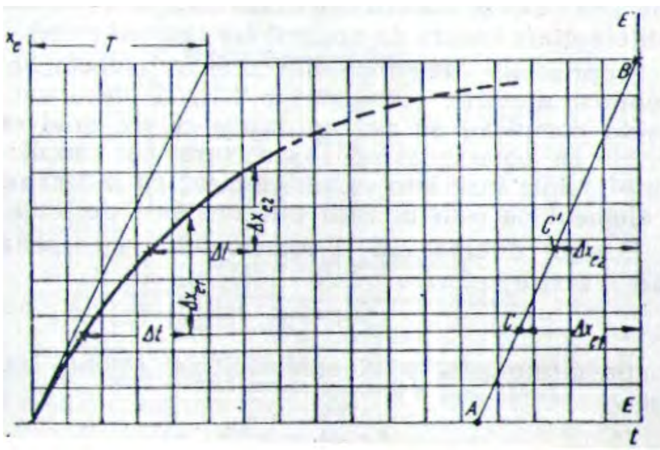


Fig. 1. Extrapolation of indexical function (reproduced in [9])

Most industrial objects are static and can be considered as objects first degree, as a pure delay element and an element of first degree, as two elements of first degree (or two) connected in series or two elements of first degree and pure delay element connected in series (or an element of second degree and pure delay element). There are possible cases when, for a more accurate assessment, is required approximations of a higher grade.

If in the case of a static object, in the conditions of the experiment, the final permanent regim is not reached and recorded only the initial portion of indexical function, it can be made the extrapolation of the curve: on experimental curve are chosen two points and is determined for appropriate time intervals, the equal segments. Next are taken the horizontals corresponding segments and the left vertical straight line EE ', as shown in Fig 1, and through points C and C' is going segment AB right to the intersection with the vertical EE'.

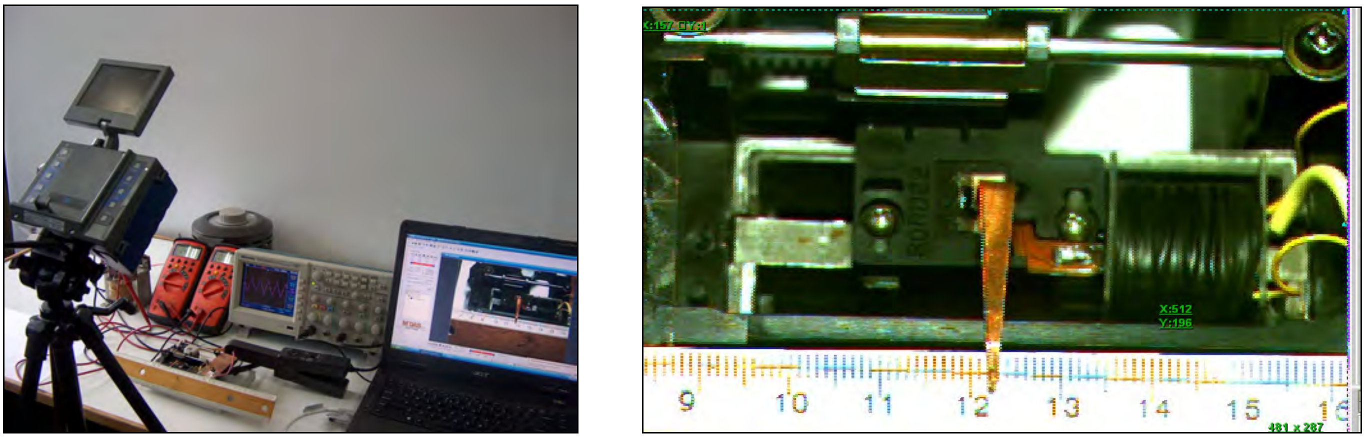
BE segment represents the final regim permanent value of the output measurement, which determines the time constant and gain coefficient of the object [9].

2. THE EXPERIMENTAL STANDS

For experimental measurements of a.c. electric motor was used two electric linear motors with shoret mobile coil shown in Fig. 2 and Fig. 3, having as input supply voltage level signal.

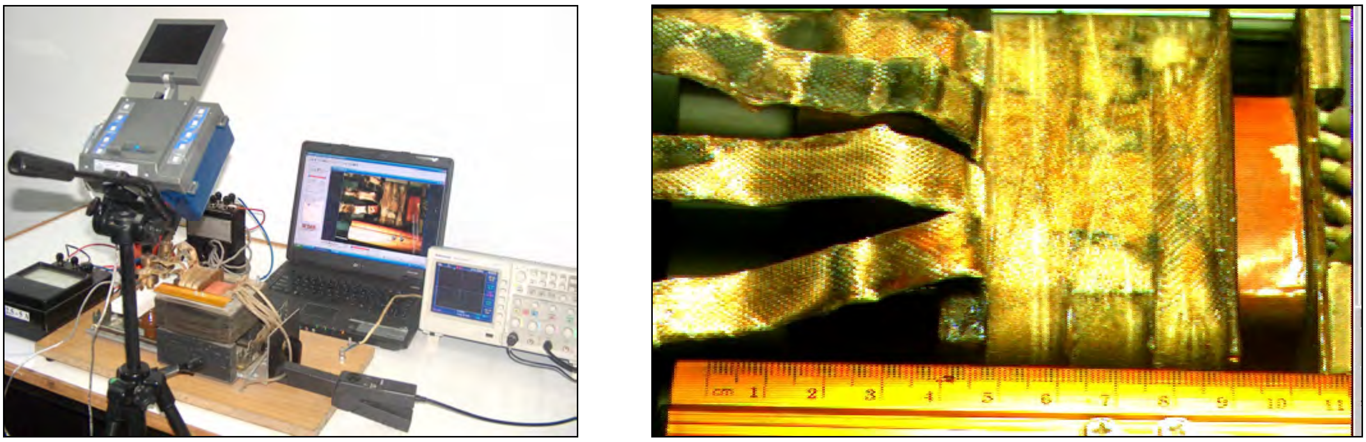
The motor with mobile coil [10], presented in the figure 2, has limited race and commanded sliding frequency. This is constituted in principle from a magnetic single-phase core achieved from electrotechnical metal sheet on which is placed a fixed winding-up. Concentric with it is settled a mobile coil in short-circuit. The mobile coil is displaced between two stops, on an axis of guide, on which glide a slide who make common part with the bobbin and with the operated element. This motor, with 300 turns in the primary winding, has been tested for the following values of input size: 10V, 12V, 14V, 16V, 18V, 20V, 22V, 24V, 26V, 28V, 30V and 32V.

The electric motor with mobile coil with variable height [8], presented in the figure 3, has settled on the column a fixed bobbin which deals just half from the height of the column and which operates by intermedium of the electrodynamics forces about of a mobile coils in short-circuit, materialized from several boulder stones, mount butt, existing the possibility of intake or take-out these boulder stones, what modifies the height of mobile bobbin and therefore, the eccentricity among the fixed bobbin and the mobile bobbin too. This second motor, with 500 turns in the primary winding and 45 turns in the secondary winding, was tested for the 220V input supply voltage level signal.



a) b)

Fig. 2. Experimental stand for studying the transient regime of an electric motor with short mobile coil [10]
a) general view; b) detail with primary and secondary coils



a) b)

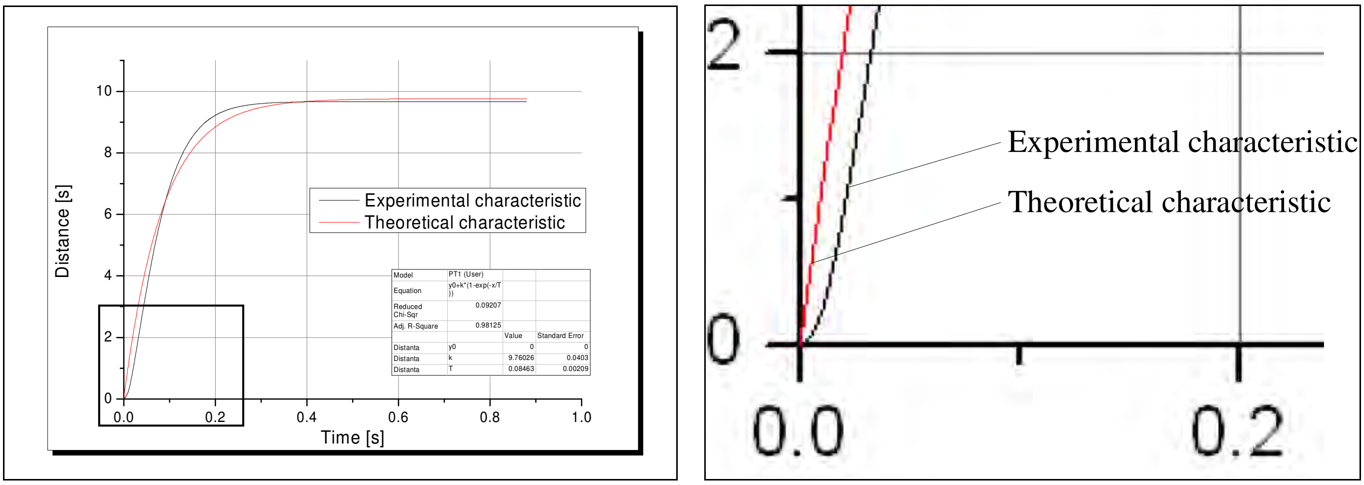
Fig. 3. Experimental stand for studying the transient regime of an electric motor with short mobile coil [8]
a) general view; b) detail with primary and secondary coils

3. ANALYSIS MODEL RESULTS

Based on the experimental data, were drawn experimental characteristics.

Because of inertia of motors, at high voltage power supply, over 18V in case of the first motor and 220V in case of the second motor (Fig. 4. a and b), the response of motor tends initially to a PT2 type system, but only for a short period (ms). On the whole characteristic, that experimental characteristic can be approximated with an answer PT1 type system.

Since the magnetic circuit of the both motors was short (due to length of the electrical steel), the preliminary experimental data were extrapolated based on theoretical characteristic function deducted from expression of a indexical function of an PT1 type system.



a) b)

Fig. 4. Details of characterics of motor from Fig. 3.
a) the characteristic of motor; b) enlarged detail of a square from a)

In Fig. 5.a, b was drawn experimental characteristic for electric motor from Fig. 2, powered by 10V a.c voltage supply and in Fig. 6 was drawn experimental characteristic for electric motor from Fig. 3, powered by 220V a.c. voltage supply. For electric motor from Fig. 2, the experimental characteristics, obtained for the other supply voltages, lead to the same results.

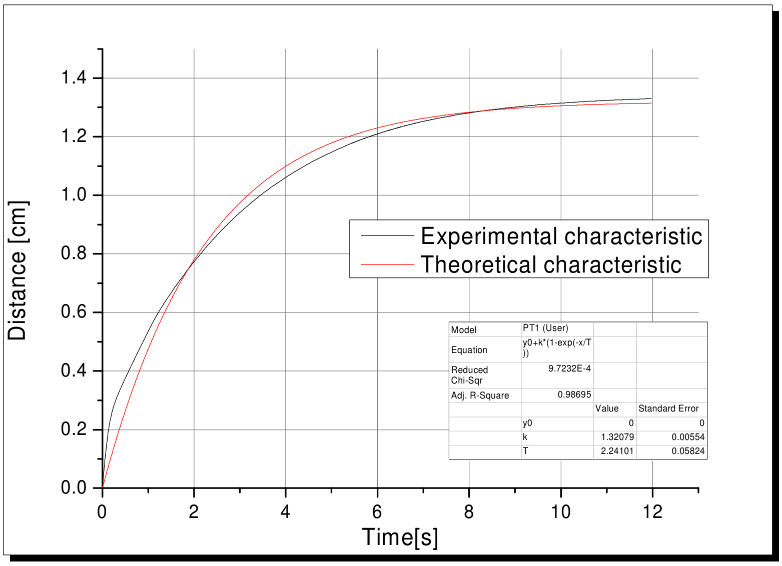


Fig. 5. Experimental and theoretical characteristics, obtained for electric motor with short mobile coil from Fig. 2.

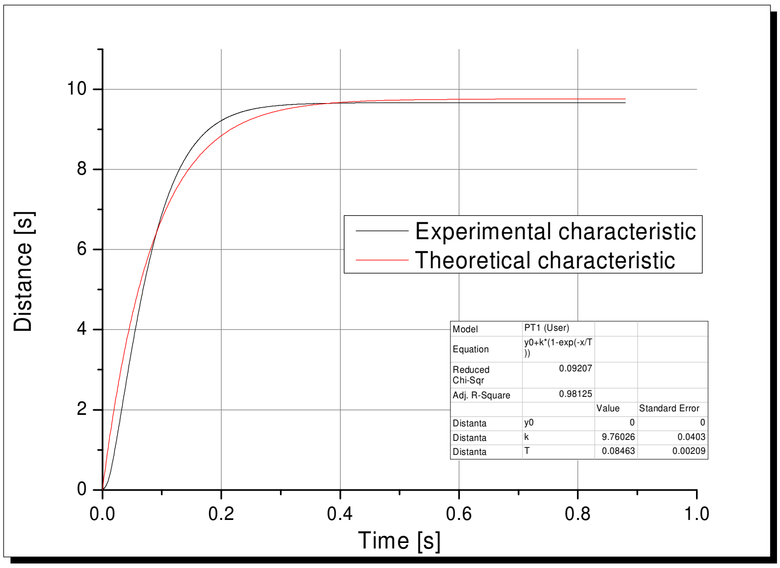


Fig. 6. Experimental and theoretical characteristics, obtained for electric motor with short mobile coil from Fig. 3.

As shown in Tables 1 and 2, which are presented the process equation and indexical functions, for both linear motors, the response is type PT1 characterized by an I order differential equations. To interpret characteristics, a comparative analysis was performed them with the theoretical results by identifying indexical functions.

Table 1

Process equation and indexical functions for electric motor with short mobile coil from Fig. 2

Experimental condition / Power suply	Process type	Process equation	Expression of a indexical function	Values of time constant and transient time [s]
10V	PT_1	$2{,}241\frac{dx_e(t)}{dt}+x_e(t)=1{,}32x_i(t)$	$x_e(t)=1{,}32\left(1-e^{-t/2{,}241}\right)$	$T=2{,}241$; $t_t=6{,}72$
12V	PT_1	$0{,}523\frac{dx_e(t)}{dt}+x_e(t)=1{,}241x_i(t)$	$x_e(t)=1{,}241\left(1-e^{-t/0{,}523}\right)$	$T=0{,}523$; $t_t=1{,}57$
14V	PT_1	$0{,}189\frac{dx_e(t)}{dt}+x_e(t)=1{,}081x_i(t)$	$x_e(t)=1{,}081\left(1-e^{-t/0{,}189}\right)$	$T=0{,}189$; $t_t=0{,}56$
16V	PT_1	$0{,}11\frac{dx_e(t)}{dt}+x_e(t)=1{,}13x_i(t)$	$x_e(t)=1{,}13\left(1-e^{-t/0{,}11}\right)$	$T=0{,}11$; $t_t=0{,}34$
18V	PT_1	$0{,}08\frac{dx_e(t)}{dt}+x_e(t)=1{,}25x_i(t)$	$x_e(t)=1{,}25\left(1-e^{-t/0{,}08}\right)$	$T=0{,}08$; $t_t=0{,}25$
20V	PT_1	$0{,}07\frac{dx_e(t)}{dt}+x_e(t)=1{,}31x_i(t)$	$x_e(t)=1{,}31\left(1-e^{-t/0{,}07}\right)$	$T=0{,}07$; $t_t=0{,}21$
22V	PT_1	$0{,}058\frac{dx_e(t)}{dt}+x_e(t)=1{,}18x_i(t)$	$x_e(t)=1{,}18\left(1-e^{-t/0{,}058}\right)$	$T=0{,}058$; $t_t=0{,}17$
24V	PT_1	$0{,}044\frac{dx_e(t)}{dt}+x_e(t)=1{,}171x_i(t)$	$x_e(t)=1{,}171\left(1-e^{-t/0{,}044}\right)$	$T=0{,}044$; $t_t=0{,}13$
26V	PT_1	$0{,}042\frac{dx_e(t)}{dt}+x_e(t)=1{,}086x_i(t)$	$x_e(t)=1{,}086\left(1-e^{-t/0{,}042}\right)$	$T=0{,}042$; $t_t=0{,}126$
28V	PT_1	$0{,}041\frac{dx_e(t)}{dt}+x_e(t)=0{,}918x_i(t)$	$x_e(t)=0{,}918\left(1-e^{-t/0{,}041}\right)$	$T=0{,}041$; $t_t=0{,}124$
30V	PT_1	$0{,}039\frac{dx_e(t)}{dt}+x_e(t)=0{,}942x_i(t)$	$x_e(t)=0{,}942\left(1-e^{-t/0{,}039}\right)$	$T=0{,}039$; $t_t=0{,}119$
32V	PT_1	$0{,}037\frac{dx_e(t)}{dt}+x_e(t)=0{,}894x_i(t)$	$x_e(t)=0{,}894\left(1-e^{-t/0{,}037}\right)$	$T=0{,}037$; $t_t=0{,}111$

Table 2

Process equation and indexical functions for electric motor with short mobile coil from Fig. 3

Experimental condition	Process type	Process equation	Expression of a indexical function	Values of time constant and transient time [s]
500 turns primay winding and 45 turns secondary winding	PT_1	$0{,}084\frac{dx_e(t)}{dt}+x_e(t)=9{,}76x_i(t)$	$x_e(t)=9{,}76\left(1-e^{-t/0{,}084}\right)$	$T=0{,}084$ $t_t=0{,}253$

The time constant, implicit the transient time, for the motor presented in Fig. 2, decreases when the size of input (in this case the power voltage supply) increases (Fig. 7).

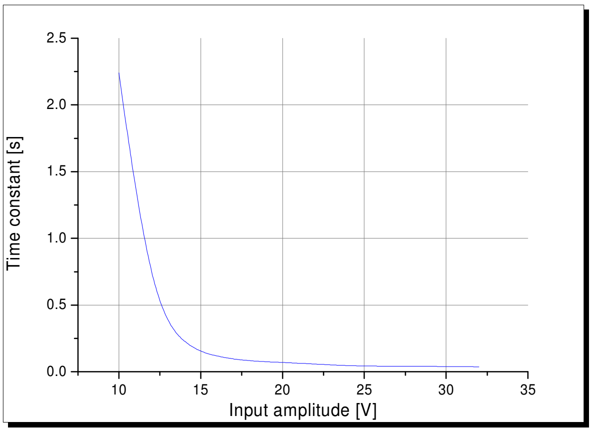


Fig. 7. Evolution of time constant depending on the size of input for electric motor from Fig. 2.

Mathematical model of electric motors with short mobile coil, presented in this paper, may be studied as an static object I order.

5. CONCLUSIONS

For experimental measurements of a.c. electric motor was used two electric linear motors with short mobile coil having as input supply voltage level signal.

The preliminary experimental data were extrapolated based on theoretical characteristic function deducted from expression of a indexical function of an PT1 type system. The response of both motors is type PT1 characterized by an I order differential equations.

Because of inertia of motors, at high voltage supply, the response of motor tends initially to a PT2 type system, but on the whole characteristic that can be approximated with an answer PT1 type system.

Mathematical model of electric motors with short mobile coil, presented in this paper, may be studied as an static object I order. The time constant, implicit the transient time, decreases when the input (in this case power voltage supply) increases.

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