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Torques Study of Oil Field Pumping Units Using a Mat-GUI-Sim Hybrid Environment

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Abstract

The paper presents a program for simulating of operation of electrical driving system of a Canadian type installation for oil extraction by pumping. The program is written using MATLAB language. Choosing of simulating parameters is made using GUI tools. As results of simulating program it can be determined moment of electromagnetic torque of electric driving machine, resistive static torque and dynamic torque. The results are transferred in Simulink environment where will be represented in chart, the time evolution of torques from driving systems.

Key words: *electric drives, asynchronous machine, simulation, MATLAB*

Introduction

In paper [1] we evoked the possibility for modelling of an oil extraction drive of an installation by Canadian type, by presenting modelling of an asynchronous tall bars motor (which is usually used for driving of such kind of extraction installations).

This precedent work concluded that it can be realized a detailing of equations for electrical part, but the solver, which is used for solving of specific Cauchy problem, must be a special one, because it necessities using of a Jacobi matrix for Cauchy equations and, eventually, a study of rigidity of the given Cauchy problem. In this manner, some of these detailing equations can considerably increase the programming effort and computer time. This is why we have to analyze justifying of these detailing of equations in report with a driving parameter (for example, value of force, which appears in the superior part of pumping tube, during a complete pumping cycle). In principle, such kind of working program can be only a complex program of studies, with a lot of aspects and derivations that can not be all included in one operating system. This is why, we decided to work "sequentially" starting from a well-endowed basis, having some perspective for future developing.

In this idea, it was considered that using a hybrid Mat-GUI-Sim environment can be very useful. This environment can be presented in form of some programs realized in MATLAB, using Graphical User Interface (GUI) tools, very useful for the programs user, with transferring of some data obtained in Simulink environment, which can be easier processed and than coming back in MATLAB working window. Actually, there is a single working environment: the MATLAB environment, but we try to use some of its basis extensions : GUI and Simulink together with all their "developments" that can grow very much the efficiency of some studies.

Methodology

The main program, which is realized in MATLAB, is referring to oil extraction using a Canadian type installation. In particular it is realizing data gathering for determining of main torques that can appear: resistive static torque, dynamic torque, total resistive torque (static and dynamic component) and electromagnetic torque moment of driving motor.

Data resulted by simulation are transferred in the Simulink working environment, where is realized a graphical representation of time variation of torques from driving system.

Program Presentation

Initial session of the program contain a succession of user graphical interfaces.

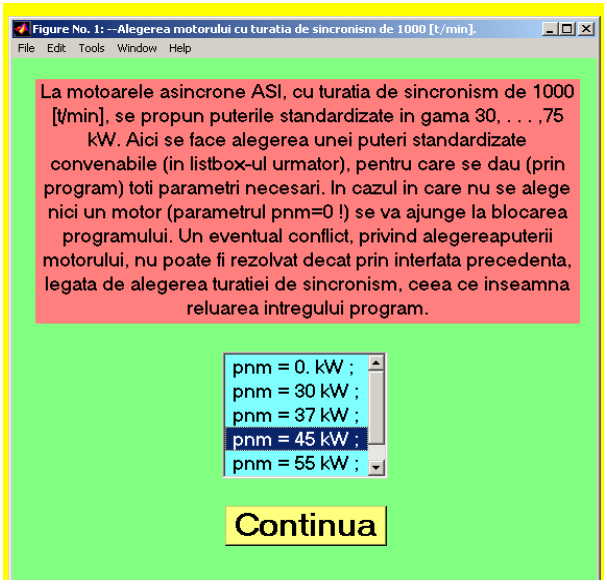

Fig. 1. Interface for choosing of motor power.

Fig. 2 Example for combined use of interfaces.

The first interface contains information about the type and characteristics of pumping unit, about the depth of the well and characteristics of pumping tubes.

In the next interface there are given information about parameters of mechanical structure, which can be modified. Next, the user should choose parameters of mechanical structure, synchronism rotation and power of electrical machine, the integration step and the modality of processing, saving and storing of simulation results.

For example, in figure 1 is presented user interface for choosing of a standardized value of power for electrical driving machine. By using a listbox, it can be seen the whole range of available motors so that the user will be able to choose a convenient value.

At the top of the screen there is an informative message about the choosing of a motor. This information is useful both for a less-experimented user and for developer of the program. The pushbutton <Continua>, by its callback function allows to the user to continue the main program. Other interfaces have other variants, which are specific to the needs, respectively to the ramifications of the main program. For example, in figure 2 it is presented a working combination between an interface, which is asking establishing the value of a program parameter, named „fiseaut" and "input" function of MATLAB working window, which is used for establishing the asked value (using the keyboard).

In this situation, by a click on the "Continua" button, the interface is deleted and after accessing the "Enter" button, in the left corner of the MATLAB working window , by "input" instruction is appearing the asking: „FISEAUT, in gr. sexagesimale = ...". The user must type at keyboard the wished value. Of course, there are another variants for using of GUIs, inside of other programs, that are more complex and which are very useful both for the user and for the programmer too.

Discussing about data processing from a MATLAB working window in a Simulink working window we can say that everything is reduced to the transfer of data from MATLAB working space in that of Simulink. After a proper processing of data, the user can return in the MATLAB working space, together with a proper set of data. This can be done by a special „preparing" of data that will be transferred, using MATLAB. After that, it can be used the command for opening working window of Simulink . This action is reduced actually only to noting the given name of the respectively window. Using Toolbar of this window, by a click on "Simulation" --→ "Parameters" --→ the tab "Workspace I/O", we will have opened the corresponding operation fields. On the top left is the option "Load from workspace" (on the right is the option "Save to workspace"), where it will be chosen the check-box "Input" In the field on the right, it can be typed the form of expression of data which were transferred and prepared in MATLAB window.

On the bottom of the opened tab can be founded the field for establishing the "Format" of transferred data, in 3 variants: "Structure with time", "Structure", respectively "Matrix". Every format has its own specific (it seems that "Matrix" format is most used). In the field "Decimation" it will be introduced the decimation factor; for a value equal with "1", it will be taken into consideration all transmitted data. For the given case, the working window of Simulink is shown in figure 3.

Here are present five input blocks, for indices "IL" of the four pumping phases: for electromagnetic torque ME, for resistive static torque MSR, for dynamic torque MD ant for total resistive torque MRT. Their representation is made inside of four oscilloscopes "in combination" with index IL, for observing the behaviour of torques during the four pumping phases. In oscilloscopes 4 and 5 it can be done other combinations: oscilloscope 4 has 3 axes and on oscilloscope 5 appear 3 curves (having different colours) to allow some evaluations. In figure 4 is presented the screen of the oscilloscope for the combination "IL+ME+MSR" (IL=1, MSR=2, and ME=3).

It can be observed very well the effects of passing from a pumping phase to another and a good accord between the value of electromagnetic torque and the value of resistive static torque. There is a small gap between the two curves because the time constants, which are different for electrical and mechanical part of the drives.

Following out the oscilloscope for the combination "IL+ME+MRT", we can observe that practically, the two curves ME+MRT (total resistive torque) overlap each other. For this reason appears only one curve, having the same colour.

Analyzing the obtained curves, we can observe "the shocks" of the torques that are produced during the passing from a pumping phase to another; these are important by their value and they have a very quickly variation. If we use a "zoom" function for a "passing" from IL=1 to IL=2, we can obtain a better image. In figure 5 is presented such a kind image. The efforts, which are produced in this zone, are, obviously, very large and they redound to the whole kinematic chain.

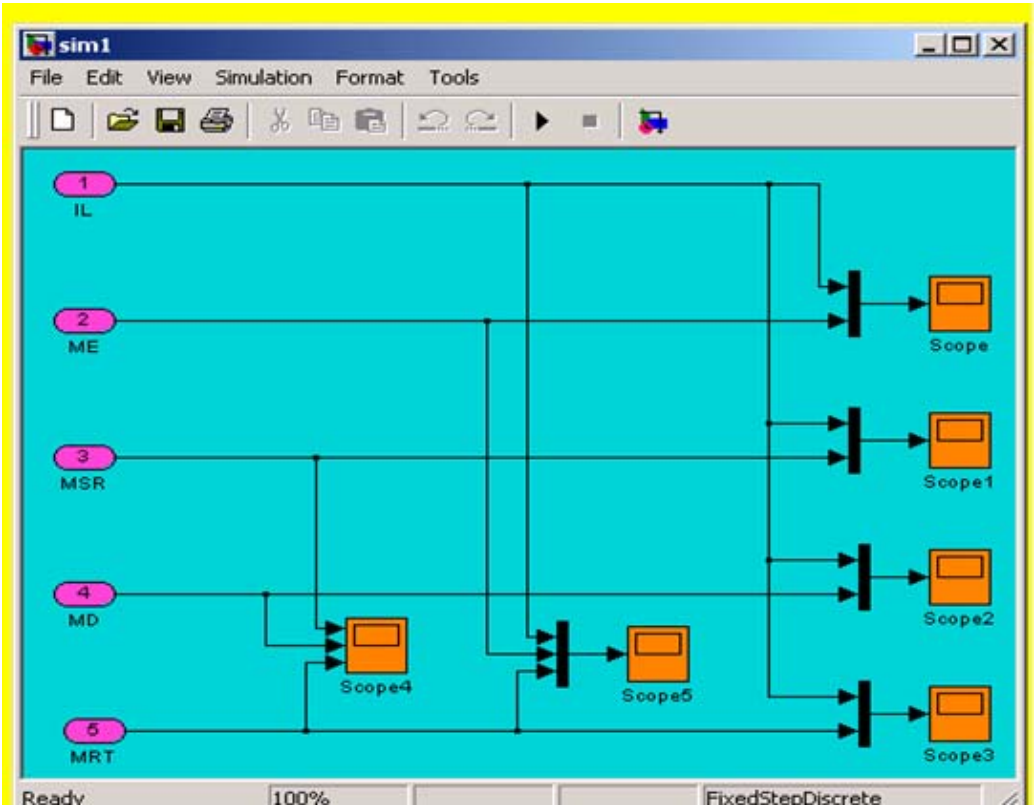

Fig. 3. Working window of Simulink for the considered example

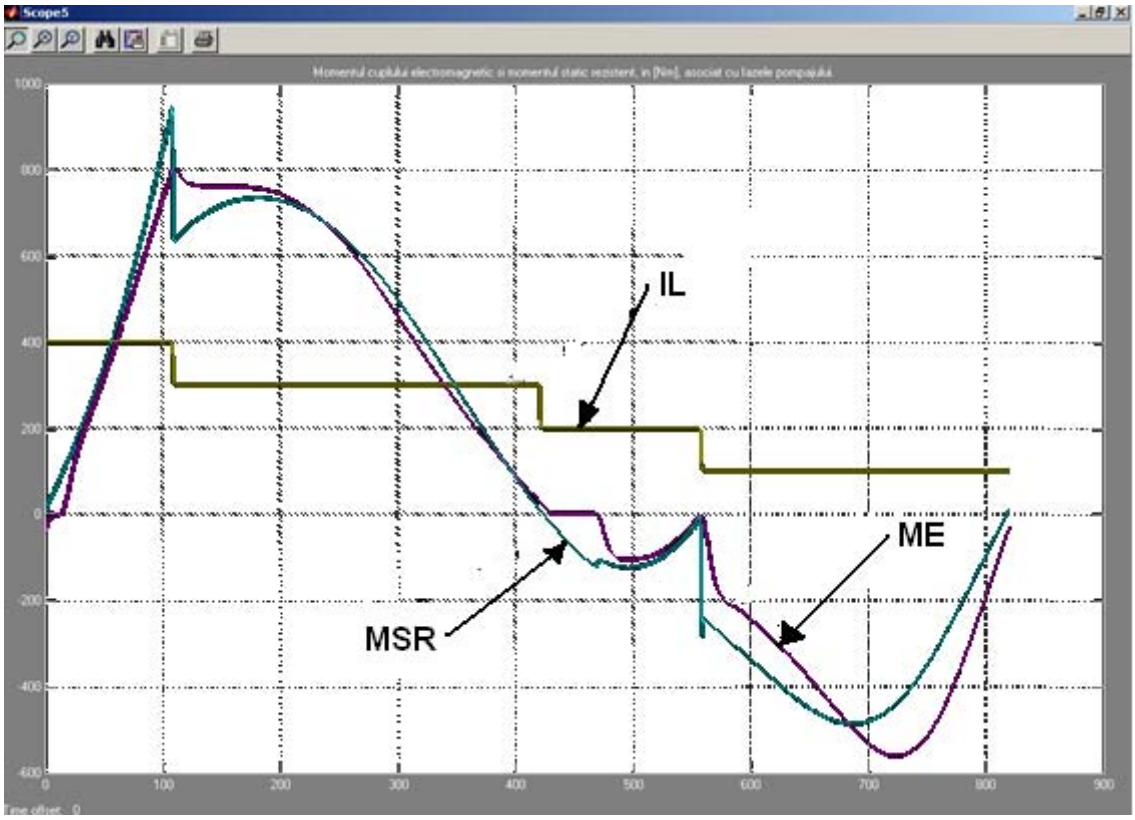

Fig. 4 Oscilloscope screen for combination "IL+ME+MSR"

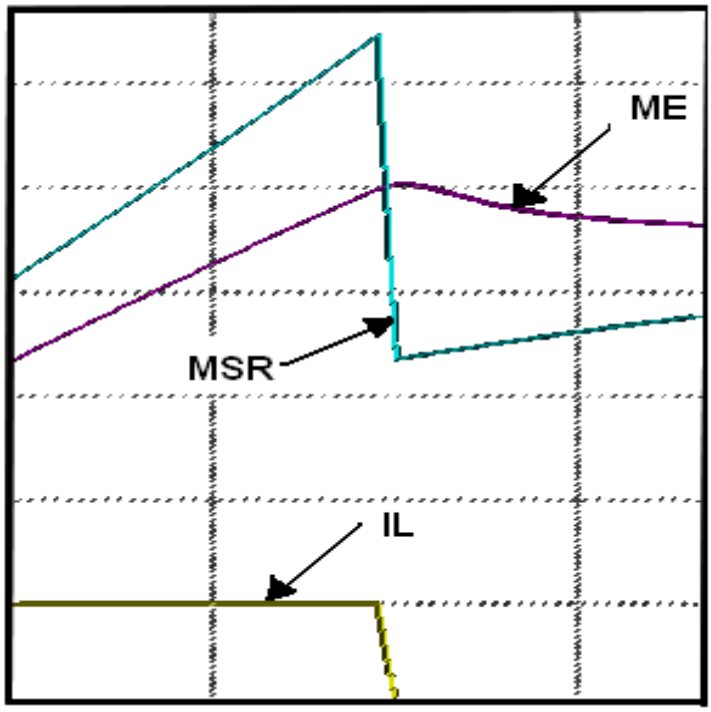

Fig. 5 Detail for passing from the first pumping phase to the second.

It is true, that the drive model do not take into consideration the elasticity of the system, which can undertake, partially, the developed energies in a very short interval, respectively can diminish the "shocks" which are produced. Here we can talk about an improving of considered model. In the same time, we must consider that this kind of installation executes a complete pumping cycle in approximatively 6.544 seconds. This means 9.17 complete pumping cycle per a minute and the fatigue study for some components can have a larger analysis field.

The behaviour of asynchronous machine, which works both in motor regime and in generator regime, in a complete pumping cycle (which means by 9.17 times per a minute) represents an important study field. In this case too, there are a lot of problems at passing the machine from a regime to another, if we consider the quantity of active energy, which is delivered back in the enery supply network.

Conclusions

In case of some special studies of electromechanical drives, the hybrid variant "Mat-GUI-Sim" can be very useful because it allows approaching of different "ramifications" of some complex study programs using a more participative contribution from user. This can involve a programming effort substantially increased.

Having permanently the possibility "to choose", it can be obtained easier the conclusions that are necessary for improving of program. In this case, using of Simulink is relative simply. It can be sawn only as demonstrative, but in some complex cases, realizing of some processing parts using blocks of Simulink can be more convenient. After that, the user can eventually return in MATLAB working window to continue his work.

The important advantage in case of using a Simulink window is the user access to all its "derivate functions", not only to Simulink blokes libraries. In this manner, extension of studies can be unlimited.

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Studiul cuplurilor la o instalaţie de extracţie a ţiţeiului prin pompaj cu ajutorul unui mediu hibrid Mat-GUI-Sim

Rezumat

Lucrarea prezintă un program de simulare a funcţionării sistemului de acţionare electrică a unei instalaţii de extracţie a ţiţeiului prin pompaj canadian. Programul este scris în mediul MATLAB. Pentru alegerea parametrilor de simulare se foloseşte Grafical User Interface. În urma simulării se determină momentul cuplului electromagnetic al maşinii electrice de acţionare, cuplul static rezistent şi cuplul dinamic. Rezultatele sunt transferate în mediul Simulink unde se reprezintă grafic evoluţia în timp a cuplurilor din sistemul de acţionare.