ABOUT SOME POSSIBILITIES FOR OPTIMIZING OF OPERATION REGIMES OF ASYNCHRONOUS MOTORS USED IN DRIVING OF DEEP PUMPING INSTALLATION

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***Abstract* – The paper analyses the possibility to optimize the operation parameters of asynchronous motors, which are used in driving of oil extraction installations by Canadian pumping. These motors have a relative low loading and the optimization is made by modifying of supply voltage.**

Keywords*: : *induction motor, deep pumping, optimization.

1. INTRODUCTION

Oil extraction installation by Canadian pumping are driven, in most of cases, by asynchronous motors having tall bars. Specificity of this kind of drives is that they demand a very high starting couple and choosing the driving motors is made, first of all, having in view the fulfilment of this deziderate.
In stabilized operation regime, the driving motor has a load which is relative low, the level of load being influenced by an unproperly choosing of the motor.
In paper [1] is set out that in a study of oil well group it were founded driving motors having the loading coefficient very small (17 ... 25%) and in [2] it is specificated that the most of analyzed well had the motors with a loading coefficient between 25...40%.
In such an operation regime it is obvious that energetical parameters of well pumping installation are relative at a low level. This is why the present subject of this paper is important.

2. AN OPTIMIZATION POSSIBILITY

It is sustained the idea of using a voltage regulator with thyristors, which is positioned between suply network and driving motors [2]. It will allow alternative voltage regulation in a large range, so that, for a given loading coefficient (which is subunitary), it can be realized an adequate regulation of supply voltage, respectively it can be obtained a maximization/minimization of some energetical parameters of motor: efficiency, power factor, total loss in power, absorbed power.

2.1. Modelul matematic si metodologia de simulare

Taken in consideration the mathematical model [3] for calculus of energetical parameters of the driven motor, it was conceived a computer program using as programming environment MATLAB. This program take into consideration a set of asynchronous motors having ASI type, which are used in driving of oil extraction installation by Canadian pumping. There are known catalog data for these kind of motors, which can have synchronism rotation by 1500, 1000 and 750 rot/min. The program allows simulation of operation for other type of motors, which are different by those that are existent in program database, using a catalog data request dialog during the software running.
In the initializing section of simulation program there are forseen many GUI interfaces for communicating with the user. By this interfaces, the user can choose synchronism turation of electrical driving motor. An example of this kind of interface, which allows selection of motor power, is presentad in figure 1.

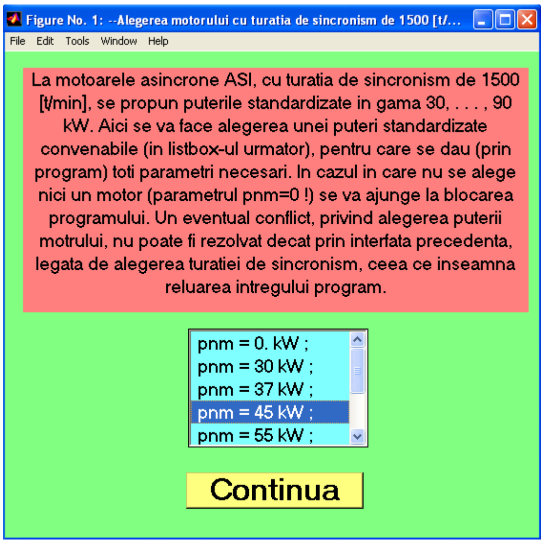

Fig.1 Interface for choosing of power of electrical motor

Having in view that in stabilized operation regime, the driving motor remains with a relative low load, for simulating, using „input" function of MATLAB, it can be established load regime of the motor according with its nominal electromagnetic couple moment.

For different values of supply voltage, the program can determine the following data:
- sliding;
- loss in stator, [kW];
- loss in rotor, [kW];
- electromagnetic power,[kW];
- loss in iron, [kW];
- mechanical and in ventilation loss, [kW];
- useful power at the shaft, [kW];
- absorbed power by motor, [kW];
- total loss in motor, [kW];
- efficiency, at a given supply voltage
- total reactive power, [kvar]
- apparent power, [kVA]
- power factor, [cosφ]

After processing of these parameters, the program will detemine:
- minimal value of loss and the value of supply voltage which allows obtaining of this minimal value;
- minimal value of absorbed power and the value of supply voltage which allows obtaining of this minimal value;
- maximal value of power factor and the value of supply voltage which allows obtaining of this maximal value.

It will be made a graphical representation in function of the following parameters: power factor, efficiency, loss in motor power and absorbed power from supply or combined variants.

2.2. Simulation results

For simulation it was choosen a motor having nominal power by 45 kW and a synchronism turation by 1500 rot/min. The load factor was established at 43.7%. It were obtained the following results:
- maximal value of efficiency is 0.8461 for a value of voltage by 161.92 V,
- minimal loss are 3.4178 kW for a value of voltage by 159.28 V,
- minimal value of absorbed power is 22.1601 kW for a value of voltage by 141.0200 V,
- maximal value of power factor is 0.9271 for a value of voltage by 98.34 V.

In figure 2 on the same chart, depending on supply voltage, is presented the variation curve of loss in motor and efficiency variation curve. The curve of loss was divided by 5, so that it can be „compatible" with the representation scale of the efficiency; this can be observed in specifications that are made in ordinate axis.

The two parameters – efficiency, respectively total loss, were choosen to be represented in the same figure because they are in some way „connected" (except representation scale) by comparisson with the other two parameters, power factor and absorbed power, which have more differences, but they can be represented in separate figures.

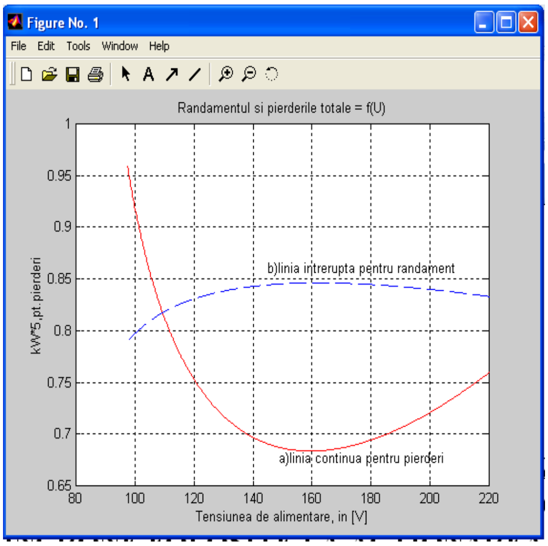

Fig.2 Efficiency variation curve and loss curve depending on voltage

What is essential, and this can be tested for any other load of a given motor, is the fact that the voltage values for which it can be obtained the maximization/minimization of the two initial parameters are closed values (the differences are quite unsignificant). In case of a system automatization for voltage regulation, taken in consideration as a automatization base the two parameters, it can consider the semisum of values of two voltage as a common voltage value.

In this idea, in figure 3 is presented the voltage curve depending on load, in order to obtain maximizing of

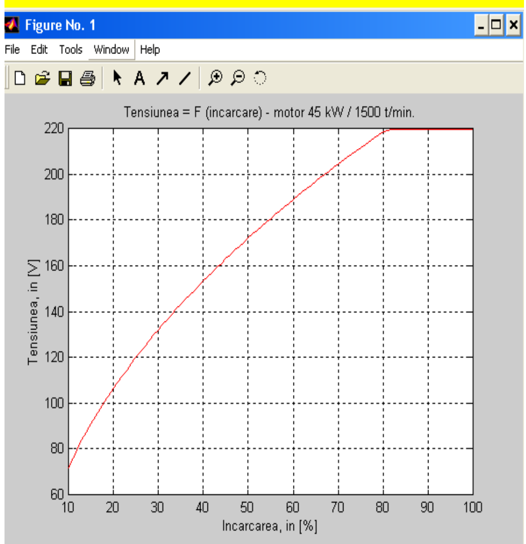

Fig.3 Voltage curve depending on load for maximizing of efficiency, respectively minimizing of total loss in motor

the efficiency, respectively minimizing total loss for the motor having 45 kW and 1500 rot/min.
Obvious, similar curves can be obtained for other parameters of the same motor or for different variants of motors. They are obtained so that they can be reused by a spline function, for any load of driving motor (in the given case, for the motor having 45kW/1500 rot/min) establishing the necessary voltage for optimizing operation regime of driving motor according with the considered parameters.
In representing of these curves, in any case, it was taken in consideration the stability in operation of asynchronous motor (having in view the method of reducing of supply voltage) at its given load coefficient
with a safety coefficient by 10%.
Voltage curve in function of motor load for a given optimum operation regime can be used for prescription of thyristors firing angle in the idea of using a voltage regulator with thyristors for motor supply. The entire process can be properly automatized.
It can be important the comaparison of total motor loss in operation at optimum voltage regime with reference to nominal voltage supply. So, for the motor with 45 kW and 1500 rot/min, if it would operate at optimum regime at a load coefficient by 30%, the total loss will be 2.8863 kW. In regime of nominal voltage, having same load coefficient, the total loss is growing at 3.825 kW (figure 2).
The energy saving is by 0.9387 kW, and for a month, the energetic consume is reduced with 675 kWh aproximatively. It is not a very important energy saving but in time and taken in consideration thousands of motors this can represent very much.
Of course, at the basis of a corect evaluation of this kind of elements has to be a detailed technico-economic calculus, which considers all aspects, not only a more suitable parameters „mate” (we can discuss about absorbed power, power factor, the load

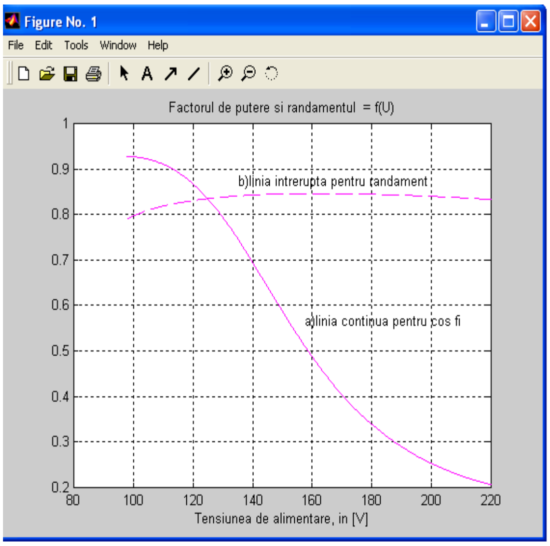

Fig. 4 Efficiency variation curve and power factor curve depending on voltage.

of line systems and transformators, the cost of modifying of installation, etc.). It is possible to take in consideration at a given load an optimal voltage, more global for more energetical parameters of the motor. In any of cases, this kind of programs can represent a starting base.
In figure 4 it is shown the variation curve of the efficiency and the curve of power factor depending on voltage.
It can be observed that for a voltage variation from 120V to 220V the efficiency fluctuates a little, between 0.83 and 0.85 and power factor decreases from 0,86 to 0,21.
In figure 5 is presented the variation curve of absorbed power and the loss curve depending on variation of supply voltage.

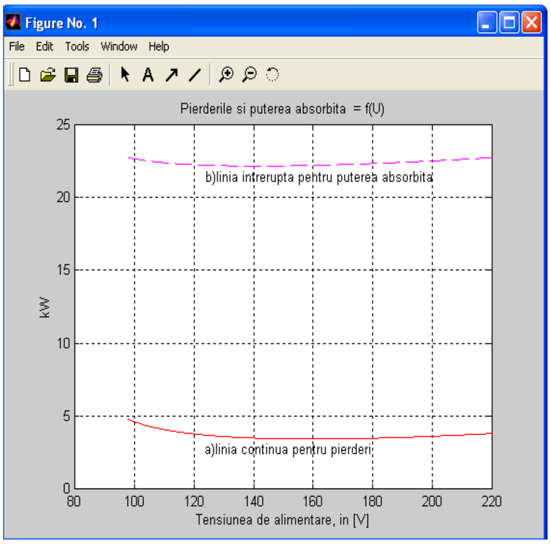

Fig. 5 Absorbed power variation curve and loss curve depending on voltage.

It can be observed that, for a voltage variation from 120V to 220V, the variation form of absorbed power is similar to the form of loss variation in time. This is confirmed by the fact that in this variation interval of voltage the variation of efficiency is small, so it was presented in figure 4.
This program is endowed with many GUI interfaces, which allow to the user to choose many variants of motors (ASI type) having many variants of synchronism turation, respectively o large range of loads (from 10 % to 100 %).
If we consider the fact that oil pumping process in stabilized regime is permanently a tranzitorium process, with modifying of load permanently and, respectively, of motor load, it can analyze the problem of automatizing of entire pumping process (ascending/descending stroke) for a certain optimum operation regime.

In automatizing process it will be considered the pumping flows and other technological and mechanical elements too.
The problem of optimizing of this kind of process, which is driven electrically, is in principle, a very complex one and, in generally it can be analyzed only from an electrical point of view, but in this case, the results will be only partial. The priorities by „technological", „mechanical" or „electrical" type, which are imposed at a moment must be taken in consideration too. Otherwise, a study by this type can be seen only like an element in a complex assembly.

4. CONCLUSIONS

Pumping installation with rocker for oil extraction are usually driven by asynchronous motors with tall bars. Their choosing is made depending on starting couple, which is necessary to the installation.
In this manner, the majority of motors appear in stabilized operation regime having a low level of load. This means that they operate at a very low energetical parameters.
Using a voltage regulator with thyristors, which will reduce supply voltage properly, it can be attend to an optimum operation regime of motor in comparison with some parameters of its (or mate parameters). In this situations it can be realized an automatizing of the driving system. Some of the curves, which are designed in certain conditions for a given motor having a given load, demonstrate these possibilities.

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