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The System of Automatic Regulation of Temperature of Compressor

Mihăiță Lincă, Alexandru Bitoleanu, Sergiu Ivanov, Mihaela Popescu, Mircea Dobriceanu

University of Craiova,
e-mail: mlinca@em.ucv.ro

Abstract

A general tendency on the global level is the development of industrial applications , on ground of aviation turboengines . In any domain – the compression of gasses , the production of electric energy , naval or train etc. – and for almost every power level , there are applications from every big company , wich designs aviation turbo-engine. First of all , these are used as : gasses generators or power groups for compressing natural gasses plants from the extraction fields or main pipes . For this , the paper presents regulation of temperature for a compressor through the supply of the water pump which is used for cooling the oil needed for the oinment of the compressor's bearing , through a static converter of tension and frequency and the regulation of temperature

Key words – *electric drives, static converter, analysis, control*

Introduction

Gasses compressor are designed to work in relation, to a low pressure and high pressure, in the frame of a natural gasses turbo compressor's frame. The high level of compression imposed the choice of a constructive solution with the intermediate cooling between the two compressors otherwise there will be low results of the process and high temperature of the gas release. The gas compressor is a spinning one, and the paper reefers to the automatic regulation of the oil temperature from the circuit of cooling and lubricating of the bearings.

The Cooling System – The Existing Solution and the technological scheme for oil's cooling

In order to mention the functioning of the turbo compressor group it is needed to assure the cooling of the compressed gasses, between the two phases, but also for the gas produced in the process. It is also needed the cooling of the oil used for the lubricating of compressor bearing and the makes part from the motor. All the three cooling system are independent to the others.

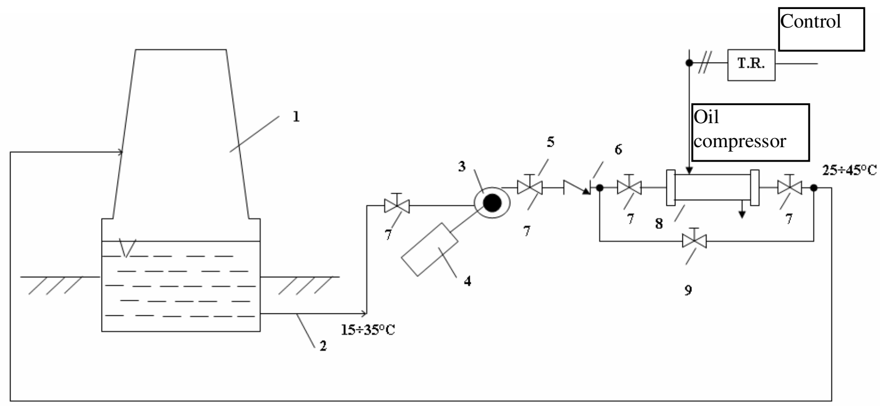

Fig. 1. The functioning of system .

The cooling of the oil needed for the ointment of compressor's bearings is realized with a cooling system described bellow. From the cooling tower (1) water is brought to the spinning pomp's vacuuming (3) now it's action electric motor (4) starts , the isolation valves (7) that belong to the system open so that the nominal current of the motor would not be over passed. The water flow is forced to go through the heat's changer (with condition that the by-pass valve (9) is closed and the isolation valves are open), after that the water flows to the cooling tower in order to be cooled. The by-pass valve has the role to mention the functioning of the installation for a relative short time in the case in which the isolation valves are closing so that the few adjustments are made to the oil cooler.

The cooling of the oil that gets out from bearings of the compressor of high and low pressure is made with the help of a heat changer in witch the heat is taken by the cooling water.

The oil's circulation scheme for ointment of the bearings of the two compressors is presented (fig.2.)

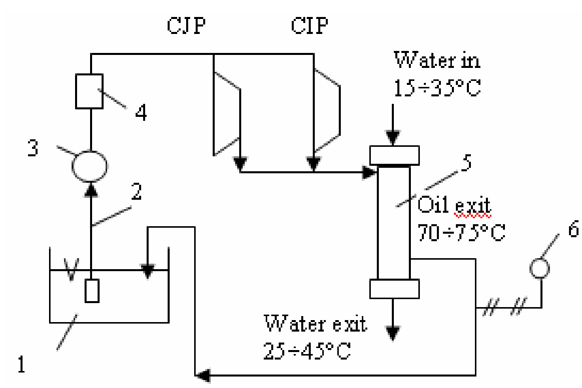

Fig. 2. The technological scheme for oil's cooling.

The system is made of: oil tank (1); oil pipes (2); oil pump (3) (driven through the box of mechanisms from the thermal engine); oil filter (4); changer for heat (5); thermo-resistance PT100 with role of a temperature transducer (6); From the changer heat, through the connecting pipes and starting from the moment where the oil pump is activated, this will head a flow of oil (depending on the engine's rotation) which will produce the lubricating and in the same time the cooling of compressor's bearings CJP and CIP. After going out from the bearings, the oil is brought at the changer for heat's entrance, where its temperature is reduced by the cooling water (which flows through the coat of the changer for heat) after that this is brought in the tank through some pipes for oil's flow. On exit pipe to the tank there is a translator for heat needed to measure the oil's temperature after it gets out from the changer for heat. The water flow is regulated by the refulating valve.

The oil cooling system is over dimensioned, having the negative effects:

- the impossibility of maintaining the oil's temperature when going out from the changer for heat in limits 70 – 75^0C, without other changing for the system;
- the refulating valve must be partially open , and cause of this it blocks;
- energy waste;
- people that during the functioning must follow regulate and maintain the oil's temperature 70 – 75^0C.

Cause of these it results that the use of this method is not indicated, even it has the great advantage of applying very easy. Cause of the arguments another method must be adopted for maintaining the oil's temperature between the two values.

The Proposed System for Automatic Regulation of Temperature

It is proposed the supply of the electric motor through voltage inverter with modulation in frequency and the achievement of a curve which will maintain the oil's temperature in limits. In this case, it the rotation grows or gets low, the characteristic of the pump changes, which also will change the functioning parameters.
This is the scheme of the proposed system for the automatic regulation of temperature.

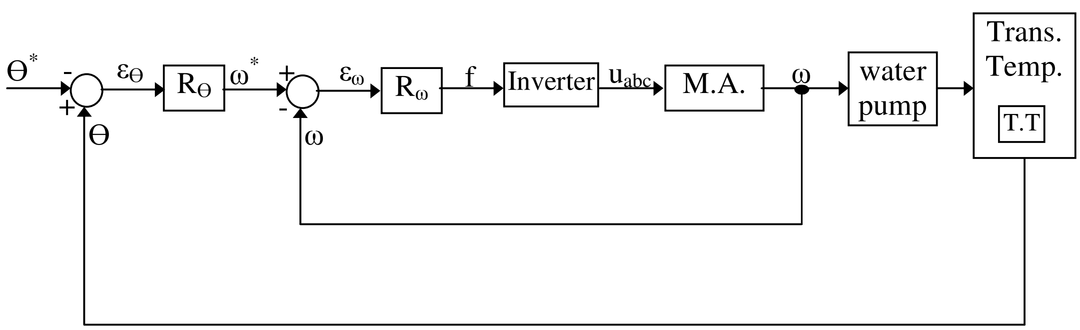

Fig. 3. The scheme of the proposed system for the automatic regulation of temperature.

where: R_Θ- temperature regulator;

R_ω- speed regulator;

Inverter – inverter with modulation in frequency;

M.A – induction motor;

T.T. – temperature transducer;

Θ^* - prescribed temperature (70 ÷75°C).

The inverter is made from a bridge with bidirectional elements. The elements are not solicited to an inverse voltage, and because of that they can be made by transistors, through their command it is modified not only the frequency of the resulting voltage, but also the changing of the amplitude of fundamental voltage from the converter's exit.

The transistors of every phase of the inverter are commanded with a delay of 2π/3 radians between the phases. At their turn, the transistors from a phase are commanded individually, respectively each one for a period of π radians. In this interval, the transistor is commanded with a train of impulses of constant dimension. The number of impulses that form the train is a multiple of 3. In fig. 4 it is represented an alternation of the line voltage which results. The other transistor of the same phase, during this interval (period) is not commanded at all, it will follow to lead on the other semi period, similar with the first, which will not be commanded.

In order to modify the outing frequency of the inverter, the frequency of the impulses that compose the train is changed but the dimension of t_{on} impulses is constant.

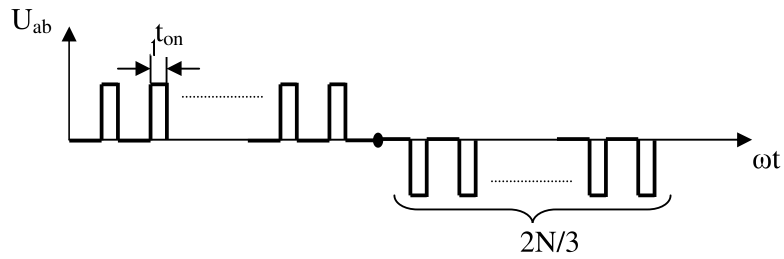

Fig. 4. The line tension .

The Modelation and Simulation of the Proposed System for the Automatic Regulation of Temperature

The MATLAB SIMULINK program was used for simulation.

Starting from the general equation of thermal:

$$p \cdot dt = m \cdot c \cdot d\theta + h \cdot S \cdot \theta \cdot dt \qquad (1),$$

and making the following suppositions:

- the coefficient of giving up heat (h) is given by the sum between the coefficient of giving up heat in a natural cooling and the coefficient of giving up heat cause by the pump $h = h_{nat} + h_{\omega}$
- the coefficient of giving up heat caused by the pump (h_{ω}) is a multiple of the speed of water pump's square $h_{\omega} = k \cdot \omega^2$
- the coefficient of giving up heat in a natural cooling is 10% (h_{nat}) of the coefficient of giving up heat caused by pump corresponding to the nominal speed (h_N); $h_{nat} = \alpha \cdot h_N$; α=0.1;

and introducing:

- Θ_{sN} temperature in a static regime corresponding to the coefficient of giving up heat caused by the pump to a nominal speed $\theta_{sN} = \dfrac{p}{h_N \cdot S}$;
- Θ_s temperature in a static regime corresponding to the coefficient of giving up heat caused by the pump; $\theta_s = \dfrac{p}{h \cdot S}$;
- T –thermal constant of electric motor time ; $T = \dfrac{m \cdot c}{h \cdot S}$

Is obtained the dependence between the motor's speed that activated the water pump and the oil's temperature from the compressors:

$$T_N \cdot \frac{d\theta}{d\tau} = \frac{p}{p_N} \cdot \theta_{sN} - (\theta - \theta_a) \cdot \left[\alpha + (1-\alpha) \cdot \left(\frac{\omega}{\omega_N} \right)^2 \right] \quad (2)$$

The significance of the present notes is:

Θ – the temperature of the oil measured in the process;

Θ_a – temperature of the surrounding system

Θ_{sN} =72.5^{0}C temperature wanted

p – the losses of the changer , that must be evacuated;

m – the mass of oil

c – the specific heat of oil;

S – the area in which heat is given to the surrounding system;

ω – speed the motor.

The Simulink model for the automatic regulation of temperature is indicated in Figure 5.

The temperature regulator and the speed regulator are PI, and the compressor's load is considered by losses value (p)

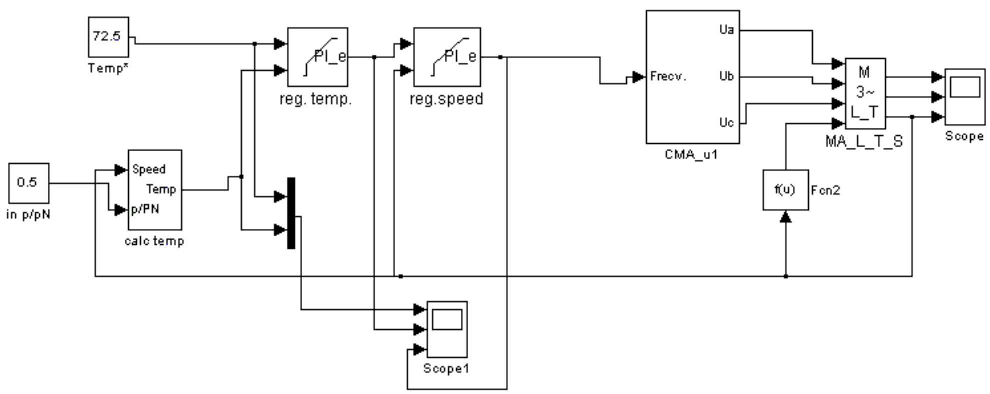

Fig. 5. The Simulink model of the system.

For p/p_n=0.5, the figure 6 shows the oil temperature and the motor speed evolutions associated with 10°C environment temperature followed by a increasing to 40°C. As it can be seen, a overshoot temperature and speed is present. After a successive rise of the temperature of the environment, the overshoot of the temperature is 1,37%, the duration of the transient regime is approximatively 10s and the stationary error is null. To assure the maintaining of the temperature at imposed level, the speed of the pump must rise from 60 rad/s to 100rad/s.

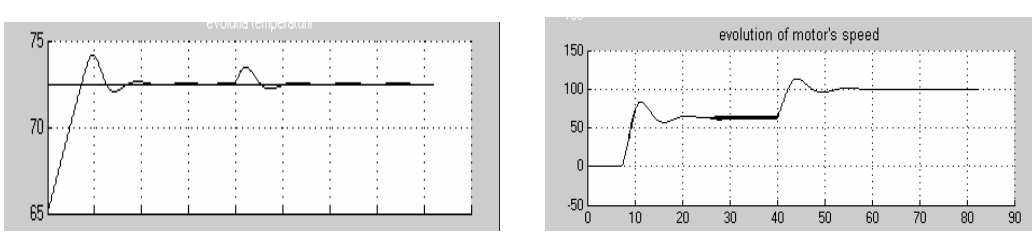

Fig. 6. The variation of oil's temperature and the evolution of motor's speed that activate the water pump.

The outputs of the temperature and speed regulators are shown in figure 7. The variations are the same with the one of the angular temperature and speed.

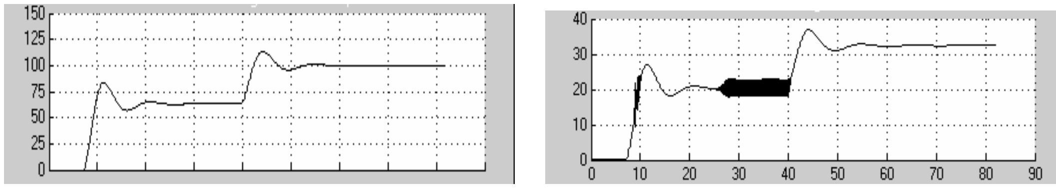

Fig. 7. The output of the temperature and speed regulators.

For p/p_n=1, the figure 8 shows the oil temperature and the motor speed evolutions associated with 10°C environment temperature followed by a increasing to 40°C. As it can be seen, an overshoot temperature and speed is present for 10°C environment temperature, only. For 40°C environment temperature, electric motor speed to reach to the nominal value.

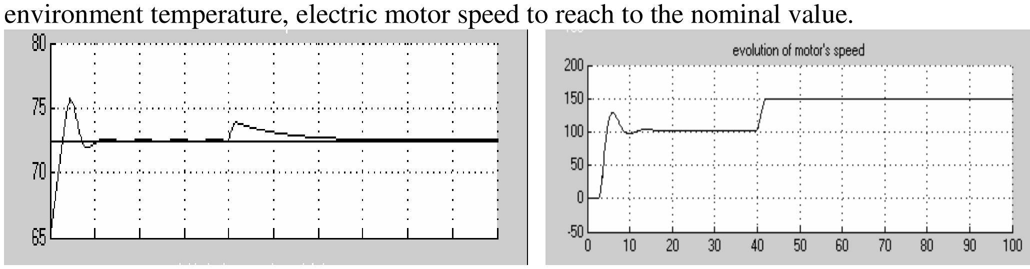

Fig. 8. The variation of oil's temperature and the evolution of motor's speed that activate the water pump for p/p_n=1.

The outputs of the temperature and speed regulators are shown in figure 9. Because the temperature regulator works at a limit value (150), at the rise of the temperature of the environment the speed response doesn't have overshoot.

The time in which the temperature stabilizes at the desired value is 2 times greater.

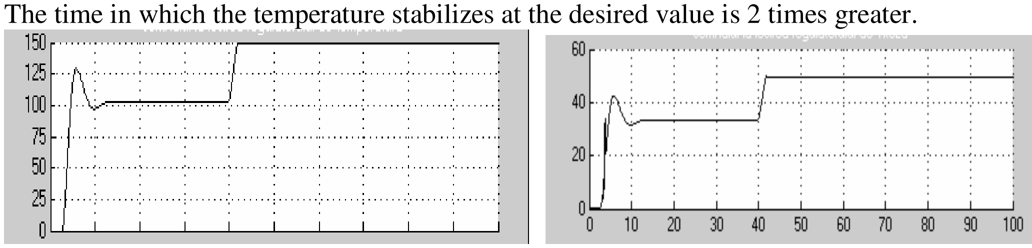

Fig. 9. The output of the temperature and speed regulators.

Conclusions

A system for automatic regulation of temperature was synthesized and the whole system was modeled under Matlab Simulink environment. The analysis of the system comportment was made for two values of the ratio p/p_n. The graphic form of the system response shows a good operation of the closed loop system.

This way the system is immune to both types of perturbations (wastes from the compressor and environment temperature) the precise speed remaining precise.

Because the stationary error is null and the duration of the transient regime is small it is estimated that the implementation of this system can lead to an important energy save.

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Sistem de reglare automata a temperaturii unui compresor

Rezumat

O tendinţă generală pe plan mondial o constituie dezvoltarea de aplicaţii industriale, terestre, ale turbo-motoarelor de aviaţie. În orice domeniu – comprimarea gazelor, producerea de energie electrică, propulsia navală sau feroviară, etc. – şi pentru aproape orice gamă de puteri, există aplicaţii ale oricăreia din marile firme constructoare de turbo-motoare de aviaţie. În primul rând, acestea sunt utilizate ca generatoare de gaze sau grupuri de putere pentru staţiile de compresare a gazelor naturale din câmpurile de extracţie petroliere sau pe conductele magistrale.

În acest sens, lucrarea prezintă un sistem de reglare automată a temperaturii unui compresor prin alimentarea pompei de apa folosită la răcirea uleiului necesar pentru ungerea lagărelor compresorului, printr-un convertor static de tensiune şi frecvenţă şi reglarea temperaturii prin modificarea debitului apei.