COMPUTER AIDED ANALYSES OF THE THYRISTOR FEEDER FOR THE ION TREATMENT PROCESS.

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Abstract

The inverter parameters should be chosen to obtain the maximum power supplied to the chamber and maximum system efficiency for the nominal physical - chemical parameters of the chamber (pressure, temperature, gas content of the main treatment of element) and the maximal change surface .

The impulse feeder has been used to supply the ion nitriding chamber, its frequency can regulated from 5 KHz ÷ 30 KHz and its power is 30 KW

Keywords

Pressure ,Chamber system ,Inverter - nitriding chamber, Simulation.

1. INTRODUCTION

From among many heat and chemical treatment methods offered on market the most effective ones proved to be the processes carried out in glow discharge conditions which always guarantee the transfer of nitrogen and other elements to the surface of steel charge, cast iron charge and the charges based on iro dust. During glow discharge processes the directed transfer of substances takes place, that is to say, the nitriding goes on mainly on the surfaces covered with afterglow.

Thus, it is necessary to maintain the minimum current density on the whole charge surface which means that nitriding is possible at abnormal glow discharge. A complete charge coating depends on the gas composition and pressure, the length of the discharge path and the temperature, material and shape of the charge.

Similar parameters determine the area of transfer of glow discharge into arcing which may result in the charge damage.

Experiments have proved that the most important factor in nitriding is the value of pressure (the highest is most desirable) which is limited by the susceptibility of the process to the transference into arcing. At the same time pressure limitation often means that the discharge does not cover, for example, the openins or the surfaces of the bearing gear wheels.

The DC feeders used so far, in practice, exhibited many essential deffects. Supplying the ion nitriding chamber with direct current caused an easy change of glow discharge into arcing at different stages of technological process. The time of charge heating and cleaning was excessively long. The necessity to lower the pressure in the chamber disadvantageously influenced the uniformity of hardening the surfaces of charges with complicated shapes.

Because of that an impulse feeder has been used to supply the ion nitriding chamber. The frequency of impulses can be regulated from 5 KHz ÷ 30 KHz.

A sequence inverter was used (fig. 1).

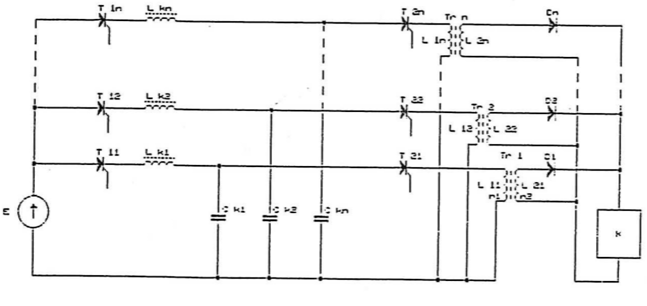

Fig.1: thyristor sequence inverter, n-branched (n is an even number) supplying the ion nitriding chamber K.

We faced the problem of making the system cooperating with the receiver which was highly unstable, nonlinear and incompletely described mathematically (because of the complexity of heat and diffusion processes). The problem was solved by performing work simulation of the feeder-chamber system. The program for simulation of nonlinear electronic systems was used.

2. THE METHOD AND RESULTS OF WORK SIMULATION OF THE TECHNOLOGICAL SYSTEM FEEDER-CHAMBER

Appropriate measurements resulted in determining an approximate mathematical formula describing the substitute resistance of ion nitriding chamber.

$R\ (\ J,\ t,\ p\ ) = A^{a}F\ (1 + b\ t\ )\ (1 - c\ \mathrm{In}\ (p))$ 2.1

The values of coefficients in formula 2.1 depend on the geometry of charge and its distance from the anode. The values of coefficients for the tested chamber with cylinder charge are: A=2240; a=0,783; b=6,97. 10^{-4}; c=0,197.

Formula 2.1 describes the chamber substitute resistance with approximately 10% accuracy for the current dencity 9 ÷ 180 A/m^2, temperature 20 ÷ 600 °C, pressure 1 ÷ 5 hpa.

The simulation was performed on the charge surface 0,5 m^2. In the model of inverter a thyristor model worked out by the authors was used . the thyristor consider such parameters as: ON/OFF time, switching ON current and conduction holding current of the thyristor [1,2,3,4] .

By carrying out a computer simulation of the technological system inverter-chamber for ion nitriding the authors tied to determine appropriate characteristics which will give most versatile describtion of the system and make it possible to find the answers to the following questions:

How to select the values of commutation inductance and capacitance $L_{k1}…L_{kn}$ and $C_{k1}…C_{kn}$, inductance of windings $L_{11}…L_{1n}$ and the gears of each transformer $T_{r1}…T_{rn}$ to obtain maximum power in the ion nitriding chamber at maximum system efficency;

What is the influence of magnetic coupling coefficient k between primary and secondary windings of the output transformer T_r ,because of possible requirements concerning mechanical construction of the high frequency transformer:

How do the characteristics of power supplied to the chamber of system efficiency change when the pressure and temperature in nitriding chamber change (these are the initial data to elaborate the process control algorithms for the constructed microprocessor control system):[5 ,6 ,7]

What are the maximum reverse voltages and currents of the inverter thyristors for the analysis chosen values of elements L_k and 1_k, $L_{11}…L_{1n}$, $L_{21}…L_{2n}$, of transformer gear and coefficient k.

3- THE RESULTS OF COMPUTER SIMULATION

To carry out computer simulation [8,9,10,11] it was assumed that the resonance frequency of circuits C_{k1}-$L_{11}…C_{kn}$-L_{kn} = const, and f =18,3 KHz , and the quality factor of resonance circuits E, L_{k1}-C_{k1} and C_{k1}-L_{11}…is constant Q =10. The losses in semiconductor elements were not taken into consideration when the efficiency was determined. Supply voltage in all cases is constant E =200 V.

The diagrams show that the power supplied to the chamber increases when the transformer gear grows (fig.3.1).

The system efficiency also increases (fig.3.2 and fig.3.3).

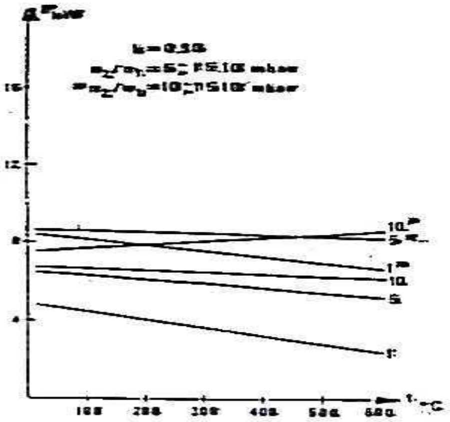

Fig. 3.1: the value of power supplied to the
Chamber in the function of temperature
For 1.5 Hpa and the gear $n_2 / n_1 = 5$
And $n_2 / n_1 = 10$

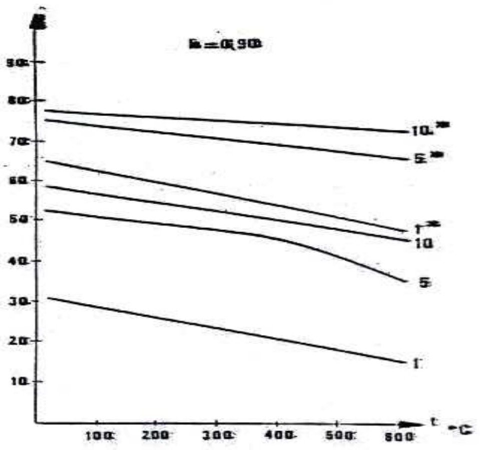

Fig.3.2: efficiency of the technological
system inverter-chamber
function of temperature for the pressure and gear
as in Fig.3.1

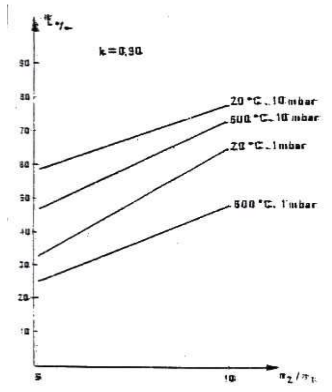

Fig.3.3: efficiency of the technological system inverter
chamber in the function of transformator
gear

The value of gear is limited by the maximum value of current impulse in the chamber in which are phenomenon does not occur and by the maximum power the given transformer core can transform [12,13] .

We have also analysed the influence of inductance $L_{11}…L_{1n}$ maintaining the constant frequency of resonance circuit. Too low value of inductance $L_{11}…L_{1n}$ causes the decrease of system efficiency (fig. 3.5 , 3.6) and increases the influence of temperature in the chamber on the value of power supplied to the chamber (fig.3.4).

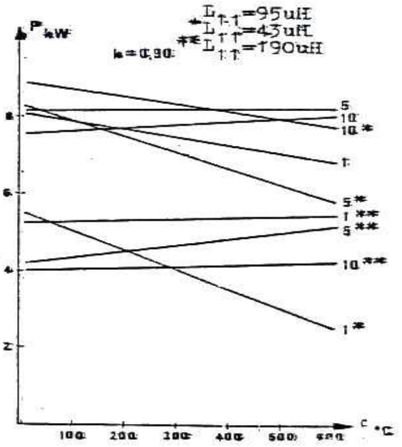

Fig.3.4: values of power supplied to the Chamber in the function of temperature, gear,
pressure and inductivity

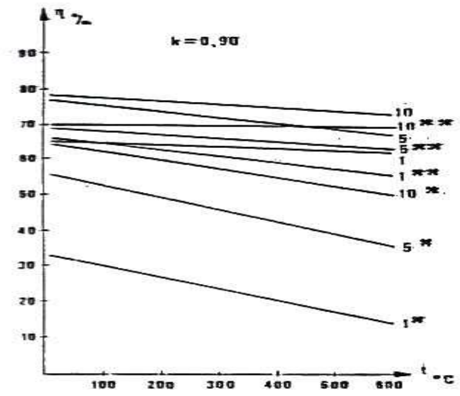

fig.3.5: efficiency of the technological

system inverter-chamber in the function temperature for the gear n_2 / n_1 = 10 and the pressure and inductivity L_{1n} as in fig.3.4

Too high value of inductance $L_{11}…L_{1n}$ also causes the decrease of system efficiency although it lowers the influence of temperature and pressure in the chamber on the value of power supplied.

The comparison of fig. (3.7) and fig.(3.8) shows there is an optimum values of inductance $L_{11}…L_{1n}$ for which the relation between the power supplied to the chamber and the system efficiency is best [14,15,16] .

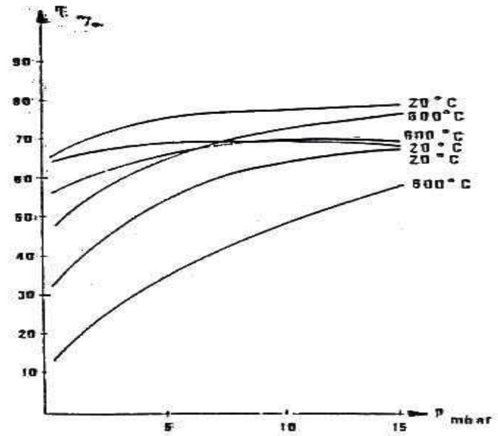

Fig.3.6: efficiency of the technological system Inverter-chamber in the function of

Pressure for inductivity L_{1n} as inFig.3.4

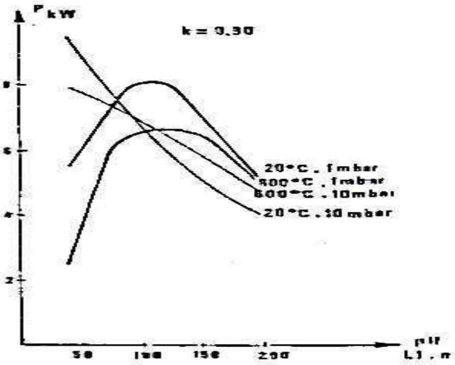

fig.3.7: the value of power supplied to the chamber in the function of iductivity L_{1n}

According to the authors, the values $L_{11}…L_{1n}$ should be chosen for the pressure and temperature at which the basic and the longest part of the technological process takes place . Coefficient k of magnetic coupling of primary and secondary windings of transformer T_r essentially influences the efficiency increase and the value of power supplied. Coefficient k maximum value is partly limited by the high frequency transformer mechanical construction.

Moreover experiments have shown that some decrease of coefficient k causes the decrease of the system susceptibility to an arc appearance in nitriding chambers.

Because of this the results presented were obtained assuming that coefficient k=0,9. Momentary waveforms of power and currents illustrate the dependances presented in fig.3.9 ÷ fig.3.14.

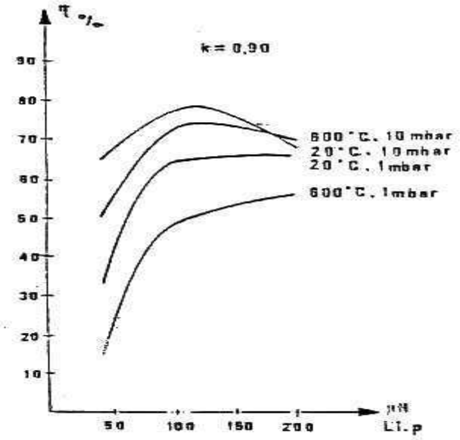

Fig.3.8: efficiency of technological system Inverter-chamber in the function of Inductivity L_{1n}

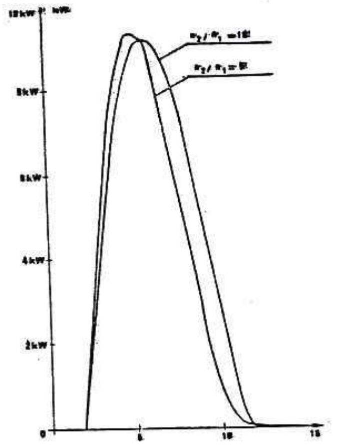

Fig.3.9: momentary value of power supplied to the chamber for t = 600°C , P = 10 Hpa

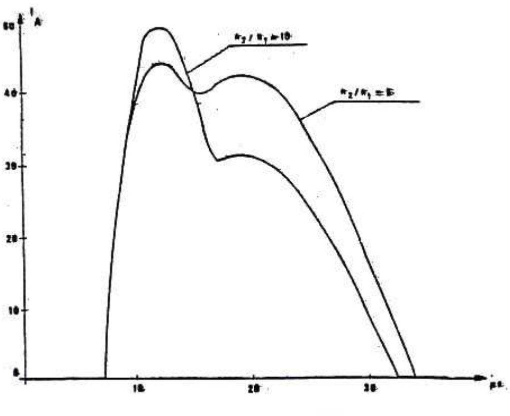

Fig.3.10: current waveform in output transformer T Primary winding for t = 600°C, P = 10 Hpa K = 0.9, L_{1n} = 95 µ H, $n_2 / n_1 = 5$ and $n_2 / n_1 = 10$

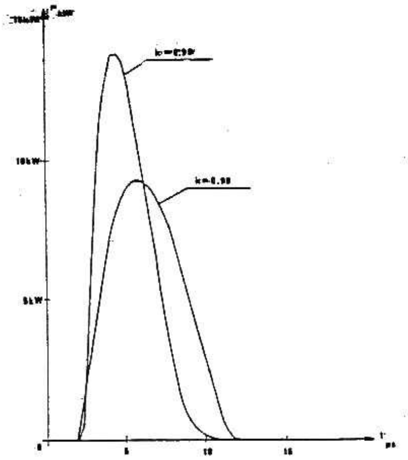

fig.3.11: momentary value of power supplied to chamber when t = 600°C P = 10 Hpa L_{1n} = 95 µ H, $n_2 / n_1 = 10$ coefficient K = 0.99 and K = 0.9

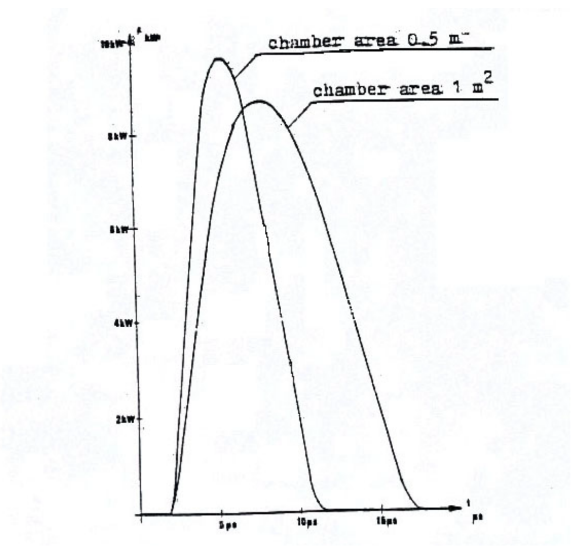

Fig.3.12 : momentary value of power supplied to the chamber for t = 600°C, P = 5 Hpa $n_2 / n_1 = 10$, K = 0.9 and L_{1n} = 95 µ H

L_{1n} = 43 µ H, L_{1n} = 190 µ H

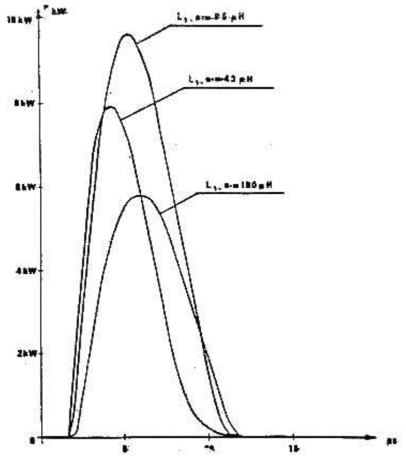

fig.3.13: momentary value of power supplied to the chamber for t = 20°C, P = 1 Hpa $n_2 / n_1 = 10$, K = 0.9 and L_{1n} = 95 µ H, and the charge area $0.5 m^2$ and $1 m^2$

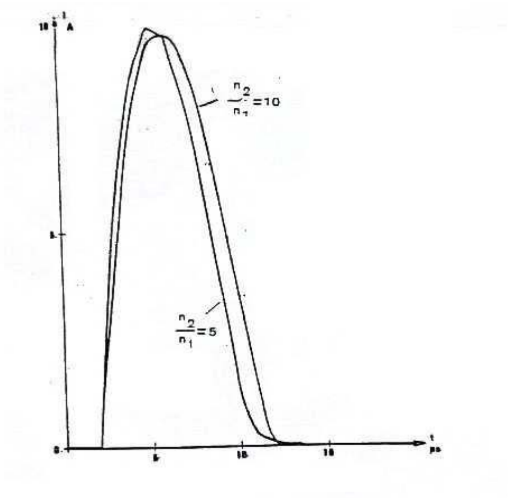

Fig.3.14: momentary value of current in the Chamber for t = 600°C, P = 10Hpa K = 0.9 and L_{1n} = 95 µ H, $n_2 / n_1 = 10$,

$n_2 / n_1 = 5$

4. CONCLUSION

1. Computer simulation of work of the technological system inverter-nitriding chamber makes it possible to determinate the optimal values of commutation elements Ck1…Lkn,L11…L1n and the gear of transformers Tr1…Trn.

It also enables us to determine the voltage and current class of semiconductor elements used .

2 . The selection of elements mentioned in item 1 is correct for the definite chamber .

charge shape and surface .

3 . To obtain a good fittment of the inverter (source)and chamber (receiver)the computer simulation of system work should be performed each time separately.

4 . Using the results of computer simulation presented a sequence inverter system has been made . Its power is 30 KW and its frequency of output voltage impulses is regulated from 5 ÷ 30 KHZ . Experimental results have proved high compatbility with the computer simulation results.

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