Model of management of an autoclave for a slag stone's manufacture with adaptation of duration and rate of rise of temperature and pressure to the chemical composition of raw materials

A.I. Kayashev
Ufa State Petroleum Technical University
Sterlitamak branch
Sterlitamak, Russia
e-mail: kayashev.ai@rambler.ru

T.V. Sazonova
Orenburg State University
Kumertau branch
Kumertau, Russia
e-mail: t.sazonowa@yandex.ru

M.I. Sharipov
Ufa State Petroleum Technical University
Sterlitamak branch
Sterlitamak, Russia

Abstract[1]

The paper proposed the construction of an autoclave for the production of gazozolosilicate' slag stones ash materials in which the temperature is regulated by six points for improvement the quality of finished goods and degrease in energy loss. The algorithms of smooth and uniform increase in temperature and pressure in the autoclave at stages of recovery from the purge and with automatic adaptation of their duration to a chemical composition of raw material of slag stone. An algorithm of pressure decrease with resolution of 0.1 mPa, in which for improvement of quality of finished goods and decrease in power inputs rate and the duration of the stage of "Smooth decrease of temperature and pressure" adapted to the chemical composition of raw material of slag stone.

1. Introduction

One of the problems in the software implementation of control systems is the selection of autoclaves in real time in a single processor of a programmable controller of one of the four control algorithms: a purge, a smooth rise and fall of temperature and pressure, and isothermal holding at a constant pressure [1]. In addition, currently used in autoclaves [2], the duration of the rise and fall of temperature and pressure is given a priori (1.5 - 2) hours) without taking into account the chemical composition (and hence the heat capacity) of the current batch of raw slag stone's. Experience shows [2] these circumstances significantly reduce the quality of the finished product and increase the heat losses. Figure 1 shows a logical diagram of the algorithm devoided of drawbacks.

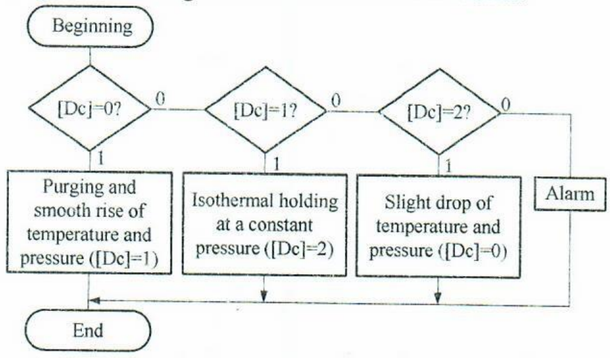

Fig. 1. The scheme of switching of control's algorithm of technological stages of an autoclave

In the scheme of algorithms for purging and smooth rise in temperature and pressure on the circuit design considerations together and to practice emergency situations put the program block "Alarm". Operators of conditional *«D_c=0?»*, *«D_c=1?»* и *«D_c=2?»* together with the cell memory D_c used for switching software blocks "purge and a smooth rise in temperature and pressure", "Isothermal aging at constant pressure" and "smooth decreasing temperature and pressure." Modify the contents of Dc is done using the assignment operator «Dc = 0», «Dc = 1" and «Dc = 2", placed in the branches of the control algorithms for the autoclave process steps which are processed by microprocessor at the end of the current stage and in the last cycle of the scan. As can be seen from Figure 1 this solution provides continuous cyclic testing of the mentioned process steps.

[1] **Proceedings of the 14th international workshop on computer science and information technologies CSIT'2012, Ufa – Hamburg – Norwegian Fjords, 2012**

The design of the autoclave which implements the proposed algorithm (Figure 1) is shown in Figure 2 (without specifying the elements that are not directly related to the control system). It is a cylindrical housing 1, which ends after loading the autoclave was tightly closed lids slag stone's 2. Their closure is controlled by sensors travel GS_1 - GS_4. A typical drainage system of the autoclave cycle [] consists of tubes 3, 4, 5 and 6 of valve [2].

Steam supply to the autoclave is made through the pipe 7 and the valve with manual drive F_1, as well as an adjustable valve F_2. On adjustable valves $F_5 \div F_7$ the steam is fed through the valve F_3, and adjustable vents on the $F_8 \div F_{10}$ - through the valve F_4. At the top and bottom parts of the autoclave the steam is fed through the valves, correspondingly ($F_5 \div F_7$) and ($F_8 \div F_{10}$). The control of pressure in the autoclave produced by pressure gauges 8, and the temperature at six points is measured by sensors (T_5 - T_{10}). The steam from the autoclave is discharged through the valve adjustment F_{11} and pipe 9.

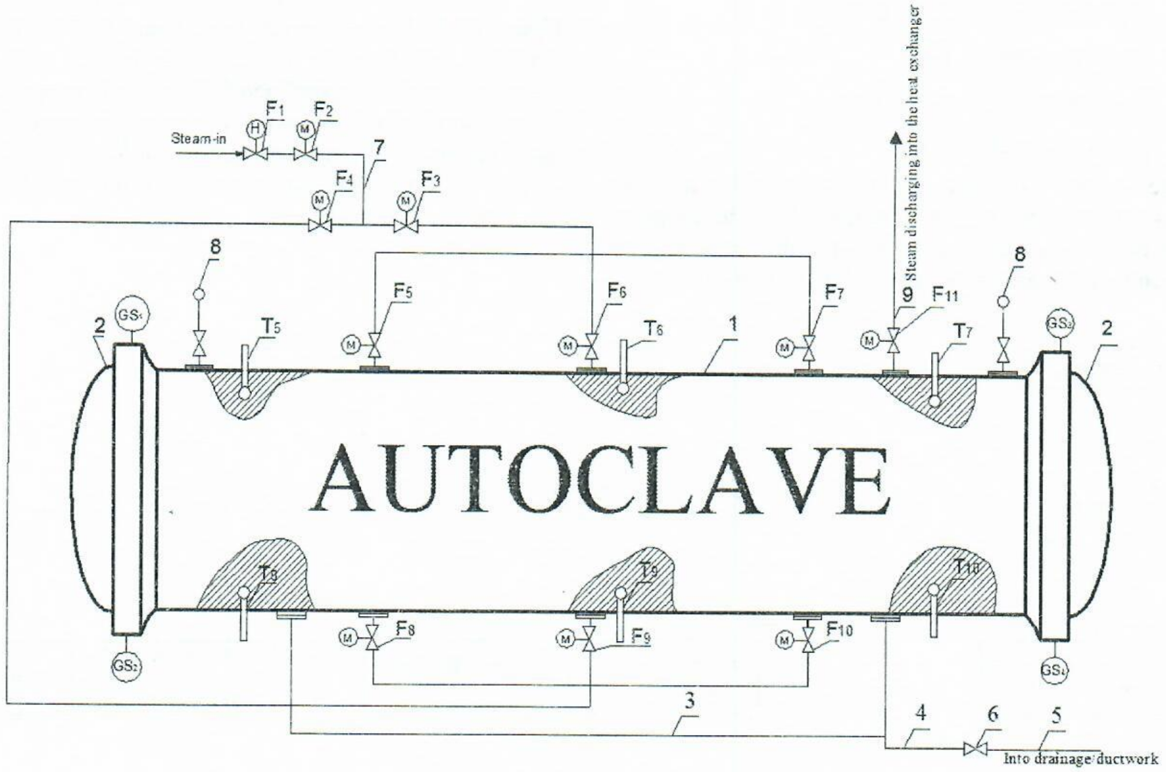

Fig. 2. Schematic design of the autoclave for the production of slag stones from the ash blocks

To prevent excessive pressure in the autoclave at the processing stage of "purging", the pipe 7 and 9 have the same cross section, and pipes exhausted from valves on the F_3 and F_4 - twice as little. For the same reasons the cross section of pipe delivered to the valves ($F_5 \div F_{10}$) is one sixth cross-section of the pipe 7.

The proposed design of the autoclave by a pair of input and control of temperature at six points allows for more evenly and in less time and with less loss of energy to provide the necessary temperature and pressure in an autoclave. This design minimizes the duration of the rise and fall of temperature and pressure in an autoclave. Ask them not as a priori given constant time interval which in most cases does not correspond to the changing chemical composition of raw materials and on the uniformity of heating of cinder blocks. Thus creating a fundamentally new conditions in order to reduce energy costs and improve the quality of the finished product in the production of slag stones from the ash blocks of the Heat Station using brown coal.

2. Algorithms of purging stages and smooth rise of temperature and pressure

The aim of purging is to replace air steam autoclave in the workspace and uniform heating of slag stones to a temperature of 50^0C . As shown by experimental studies [2] the heating of the autoclave to that temperature provides the best quality finished products at the lowest cost of energy on the assumption of that the ingate valve is open the autoclave at 50%.

To purge the logical control and recovery stages of the temperature in an autoclave provided a set of clear terms ($T_{T1} \div T_{T8}$) shown in Figure 3. Inherently logical terms ($T_{T1} \div T_{T8}$) are the arguments of two-valued logic [3, 4].

Their importance on the universal real line is described by the following expressions:

$$T_{T1} = \begin{cases} 1, \text{if } GS\cdot(20\,^0C \le T \le 50\,^0C); \\ 0, \text{if } (T > 50\,^0C)\cdot\overline{GS}; \end{cases}$$
$$T_{T2} = \begin{cases} 1, \text{if } GS\cdot(50\,^0C < T \le 70\,^0C); \\ 0, \text{if } (T > 70\,^0C)\cdot\overline{GS}; \end{cases} \qquad (1)$$
$$\cdots$$
$$\cdots$$
$$\cdots$$
$$T_{T7} = \begin{cases} 1, \text{if } GS\cdot(150\,^0C < T \le 170\,^0C); \\ 0, \text{if } (T > 170\,^0C)\cdot\overline{GS}; \end{cases}$$
$$T_{T8} = \begin{cases} 1, \text{if } GS\cdot(170\,^0C < T \le 190\,^0C); \\ 0, \text{if } (T > 190\,^0C)\cdot\overline{GS}. \end{cases}$$

Figure 2 and expressions (1) shows that the most important property set clear terms allows in times to better performance of clear logic controllers: at any given time only one clear term value is a logical unit [5].

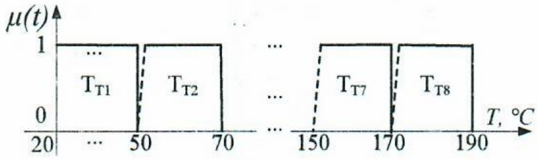

Fig. 3. The set of clear terms of interpreting the temperature in the autoclave at the stages of "Purging" and "the Rise of temperature and pressure"

The integrated logic algorithm processing steps "purging" and "The rise of temperature and pressure" is presented in Figure 4. In her statements conditional $GS\cdot SB_1\cdot T_{T1}=1$, $GS\cdot T_{T1}=1$, $GS\cdot T_{T2}=1 \div GS\cdot T_{T8}=1$ to initiate real-time execution stage, "Purging" and "Slight rise in temperature and pressure" consisting series of consecutive procedures "Smooth rise in temperature from 50^0C to 70^0C» ÷ «Slight rise in temperature from the 170^0C до 190^0C".

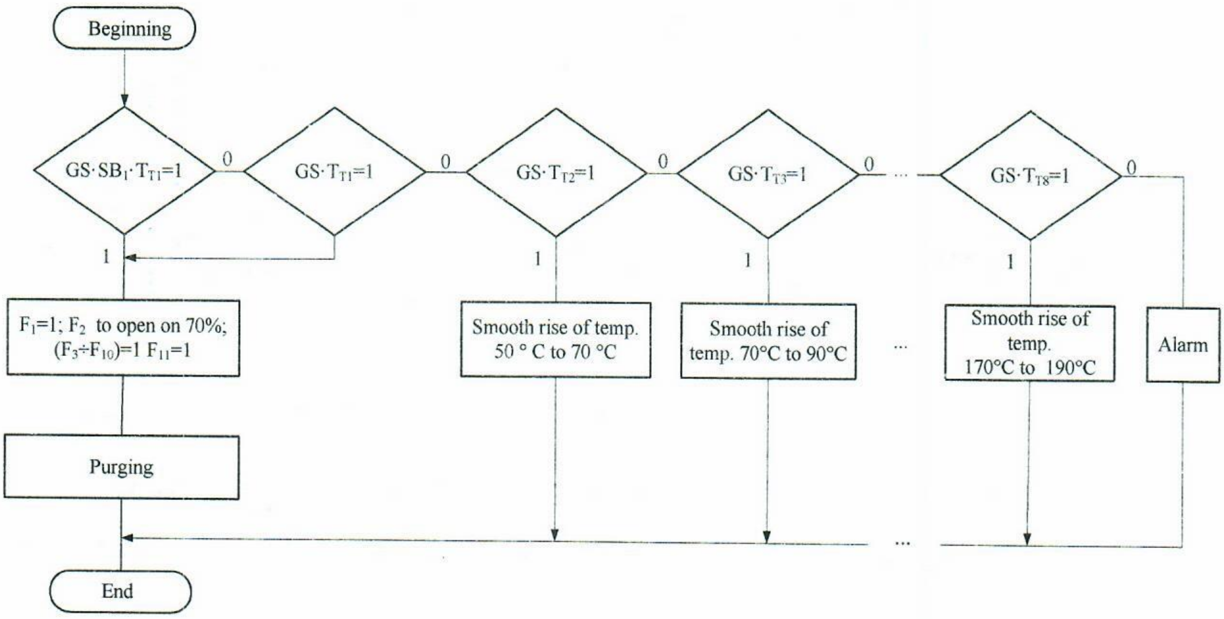

Fig. 4. The integrated logic scheme of algorithm of technological stages of purging and rise of temperature and pressure

Purge cycle is initiated when the autoclave was sealed lids $((GS_1\cdot GS_2\cdot GS_4)=GS=1)$ by pressing SB_1 (Cycle). In the case of incorrect assignment of clear set of terms generated by the message about the accident (the operator of "Alarm"). When depressurizing the autoclave is triggered blocking of the algorithm (in the conditional statements in the picture 4 $GS=0$).

The control logic gates $F_5 \div F_{10}$ at the stage of "purging" depending on the temperature sensor readings $T_5 \div T_{10}$ describes the logical model shown in Figure 5. From this it follows that the considered end stage when the testimony of all the temperature sensors $(T_5 \div T_{10})$ will be equal to or greater than 50^0C (operator $T_5\cdot T_6\cdot T_7\cdot T_8\cdot T_9\cdot T_{10}=T_{5\div10}=1$). In this case all the conditions $((T_5 \ge 50^0C) \div (T_{10} \ge 50^0C))$ equal to the logical unit in an autoclave at a temperature equal to or greater 50^0C, and valves $(F_5 \div F_{10})$ fully open for the next step rise in temperature and pressure in an autoclave.

Figure 5 shows that the stage is complete purge of the temperature reaches 50^0C in all six points at which temperature sensors are installed. In other words, the duration of the purge step in this case is determined by the heat capacity of materials of construction located in an autoclave at the current time, the party of slag stones.

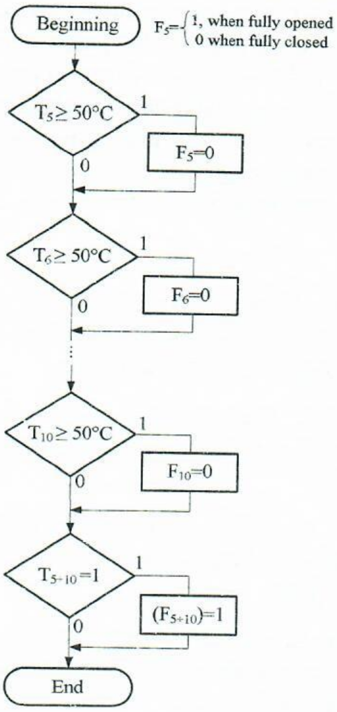

Fig. 5. The logical model of the stage of "purging" with the adaptation of temperature in the autoclave to the chemical composition of slag stone's raw

In turn, the heat capacity of materials is strictly related with its chemical composition which is varies widely in an ash slag stones of Kimertau Heat Station [1, 2]. All this suggests the feasibility of adapting the duration of the stage blowing to the chemical composition of raw slag stones and reject a priori set this parameter.

As can be seen from Figures 3 and 4 at $T>50^0C$ $(T_{T2}=1)$ procedure starts with a smooth rise in temperature in the autoclave by 50^0C до 70^0C. Its logical structure is presented in Figure 6, a.

The structure of the remaining seven treatments (Fig. 6, b ÷ f) of rise stage of the temperature is similar. The procedure for 6 h under a smooth rise in temperature and pressure is the last. Therefore it when the event occurs $T_{5 \div 10} = 1$ the operators «$F_5 \div F_{10}$» and «[Dc] = 1. Moreover, these operators are processed once and the last scan cycle procedure 6, f.

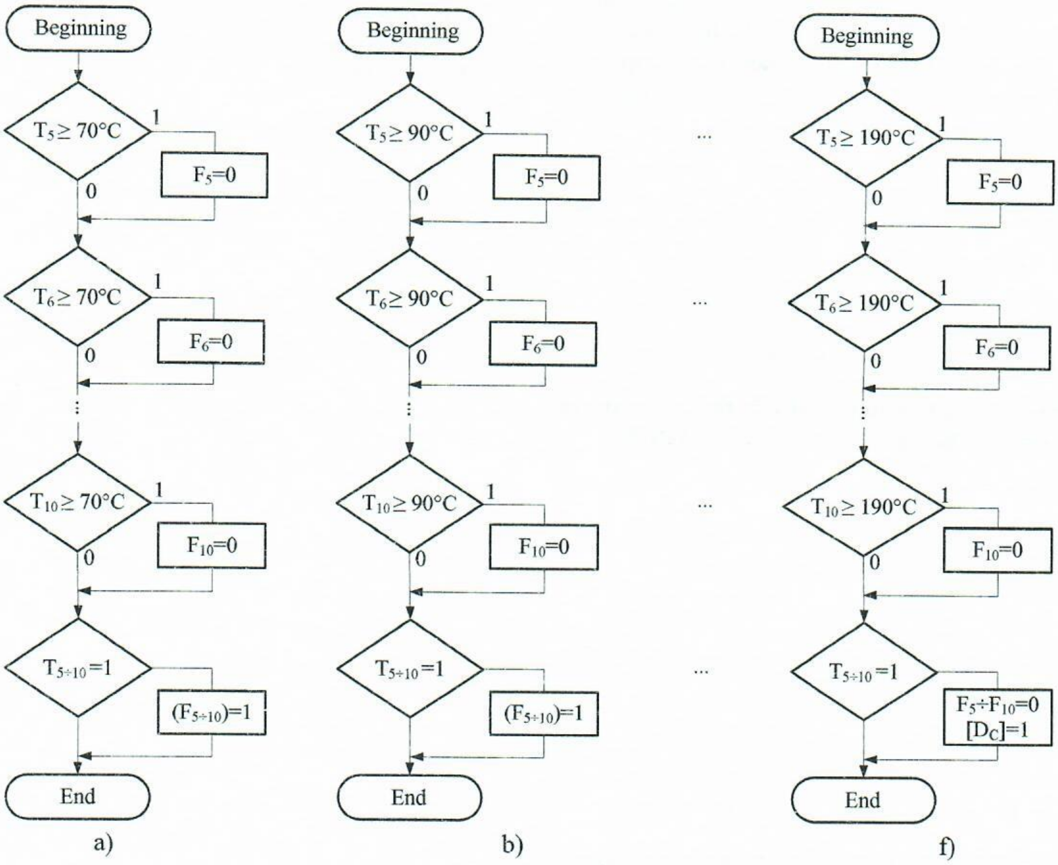

Fig. 6. The logical structure of the rise procedures of temperature in the autoclave

Figure 7 shows a family of pressure (P) in an autoclave, and then when you open the inlet valve on the (10 ÷ 100)%. Their analysis shows that they are almost linear. Therefore, there is no need to use the controller that implements the rise of pressure in time linearly. However, an important parameter in this case is the rate of rise of pressure in an autoclave with a minimum of a marriage of commercial products with a minimum loss of energy.

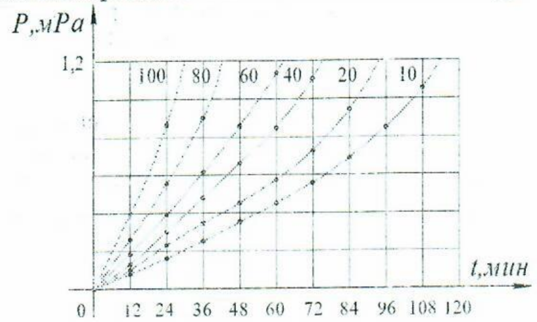

Fig. 7. Family dependences of pressure (P) in an autoclave from time at opening of the ingate on the (10 ÷ 100)%.

To address these challenges in Figures 8 and 9 show the experimental dependence of the volume removed defective cinder block (D) and the energy loss (ΔQ) of the intensity of the steam into the autoclave through a valve F_2. Figure 8 shows that at least at the stage of marriage in the autoclave temperature rise occurs when the valve is opened on the F_2 (65 ÷ 75%) and the energy losses in the autoclave will be minimal when opening the valve on the F_2 (70 ÷ 80)%. Hence the compromise degree of valve opening is F_2 (67,5 ÷ 77,5)%. Figures 7 and 8 it is shown as a shaded area.

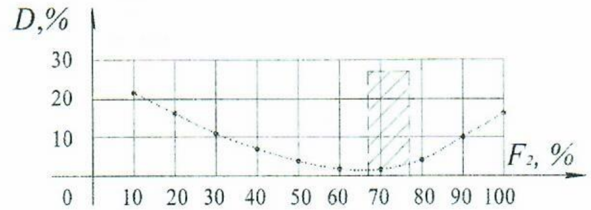

Fig. 8. Rate of rise of temperature in the autoclave at opening of the valve on the F_2 (10 ÷ 100)%

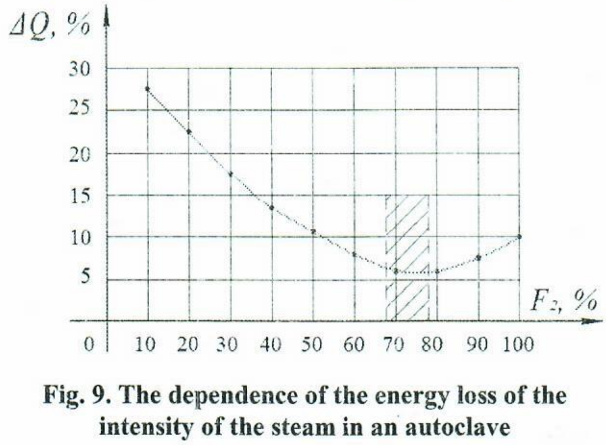

Fig. 9. The dependence of the energy loss of the intensity of the steam in an autoclave

3. Conclusions

Thus developed the algorithms of smooth and uniform increase in temperature and pressure in the autoclave at the stages of recovery from the purge and automatic adaptation of the duration of the chemical composition of raw slag stones. It was established experimentally that the stage temperature rise occurs with a minimum marriage and minimal loss of energy at the opening of the valve inlet steam in an autoclave at (67,5 ÷ 77,5)%.

References

1. Tchaus K.V., Chistov Y.D., Labzina Y.V. The 'know-how' of building materials, products and instructions. – M.: Const.publ. – 1988. – 488p.
2. Bojenov P.I. The Technology of slag stone's materials. – L.: Const. publ., Leningrad branch. – 1978. – 368p.
3. Leonenkov A. Fuzzy modeling in MATLAB and fuzzyTECH. - St. Petersburg.: BHV - St. Petersburg, 2005. - 736 p. Ill.
4. Uskov A.A. Kruglov VV Intelligent control systems based on fuzzy logic methods. Smolensk Smolensk city printing, 2003.
5. Muravyev E.A., Gabitov R.F. The concept of a clear logic control of stochastic processes with uncertainties. Mavlyutovskie read: National Youth Conference: Sat. Tp. 5 Volume 2 tons / Ufimsk.gos.tenhn.un-m. - Ufa USATU, 2010. - 301 p. P. 241-243.