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ПІДСУМКИ НАТУРНИХ ДОСЛІДЖЕНЬ МАЛОГАБАРИТНОЇ СКЛОВАРНОЇ ПЕЧІ З ПРОКАТКИ ЛИСТОВОГО СКЛА

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Анотація. Дослідження проводилися з метою отримання даних про наявність пошкоджень конструкцій печі в ході експлуатації; зміни конструктивних елементів в ході експлуатації при зміні технологічного процесу у разі, якщо такі мали місце; визначення постійних, усталених температур в агрегаті печі та на конструкції її металевої обв'язки; вивчення динамічних навантажень в агрегаті печі. У ході даного обстеження були зафіксовані зміни температур в характерних перерізах колони. Характерними перерізами колони металевого каркаса обв'язки печі прийняті три перерізи: біля оголовка колони над склепінням печі, переріз над вузлом сполучення колони з комбінованою балкою склепіння і переріз, розташований під опорним вузлом кріплення кронштейна для обпирання стін газополуменевого простору печі. Проаналізовано зміни температур у цих перерізах. У подальші розрахунки будуть внесені корективи на зміну температур по висоті, по перетинах. На підставі даних мнемосхем роботи печі і архівних даних керуючої програмного комплексу Siemens PCS 7 виявлено незначний перепад температур в період попереміної подачі факела і незначний тиск, створюваний пічними газами. Зафіксовані значення тисків пічних газів мізерно малі і в розрахунковій схемі враховуватися не будуть.

Ключові слова: скловарна піч, днище печі, склепіння печі, каркас, вогнетрив.

РЕЗУЛЬТАТЫ НАТУРНЫХ ИССЛЕДОВАНИЙ МАЛОГАБАРИТНОЙ СТЕКЛОВАРЕННОЙ ПЕЧИ ПО ПРОКАТКЕ ЛИСТОВОГО СТЕКЛА

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Аннотация. Исследования проводились с целью получения данных о наличии повреждений конструкций печи в ходе эксплуатации; изменения конструктивных элементов в ходе эксплуатации при изменении технологического процесса в случае, если таковые имели место; определения постоянных, устоявшихся температур в агрегате печи и на конструкции ее металлической обвязки; изучения динамических нагрузок в агрегате печи. В ходе данного обследования были зафиксированы изменения температур в характерных сечениях колонны. Характерными сечениями колонны металлического каркаса обвязки печи приняты три сечения: у оголовка колонны над сводом печи, сечение над узлом сопряжения колонны с комбинированной балкой свода и сечение, расположенное под опорным узлом крепления кронштейна для опирания стен газопламенного пространства печи. Проанализированы изменения температур в этих сечениях. В дальнейшие расчеты будут внесены коррективы на изменение температур по высоте, по сечениям. На основании данных мнемосхем работы печи и архивных данных управляющей

программного комплекса Siemens PCS 7 выявлен незначительный перепад температур в период попеременной подачи факела и незначительное давление, создаваемое печными газами. Зафиксированные значения давлений печных газов ничтожно малы и в расчетной схеме учитываться не будут.

Ключевые слова: стекловаренная печь, днище печи, свод печи, каркас, огнеупор.

RESULTS OF FIELD RESEARCHES OF A COMPACT FURNACE FOR ROLLING SHEET GLASS

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Abstract. These studies were carried out to obtain data on the presence of injuries furnace parts during operation; changes of structural elements during operation when changing technological process, if any; define the constant, sustained temperatures in the unit the furnace and on the design of the metal binding; the study of dynamic loadings in the unit the furnace. This survey recorded temperature changes in characteristic sections of the columns. Characteristic sections of the column metal frame furnace binding were taken three sections: the head of the column over the arch of the furnace, cross over the node mates columns combined beam of the dome and the cross-section located under the reference node of the mounting bracket for supporting walls of gas-flame space of the furnace. The changes of temperature in these sections. In further calculations will be made to adjust to changing temperatures height loft. On the basis of the data of mnemonic diagrams of work of the furnace and archival data management software complex Siemens PCS 7, revealed a slight drop of temperature in the period of interleaving the filing of a torch, and a slight pressure generated coking gases. The recorded values of pressures of the flue gases are negligible, and in the computational scheme will not be counted.

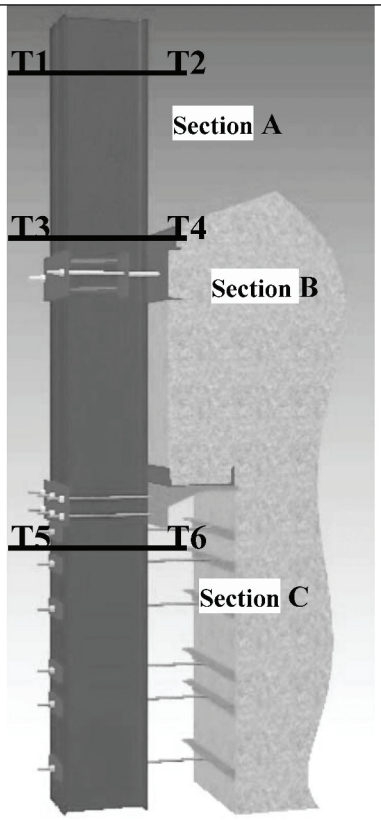
Keywords: glass furnace, the bottom of the furnace, the arch of the furnace, frame, the main part.

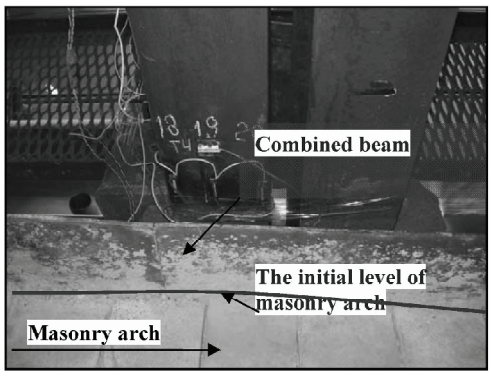
Constructive furnace and its construction of a metal frame have been studied in the literature [1–7] and presented in earlier published articles [8–10]. This survey were recorded temperature variations in cross-sections. Measurement of temperature on metal frame columns were conducted with the help of infrared thermometer with laser pointer Metermen IR608, acting in the range of temperatures from –18 to +400 °C, the error is the 2 °C. Reading is carried out at a distance of 20 cm from the surface of the investigated plane at right angles, which reduces the accuracy of measurements.

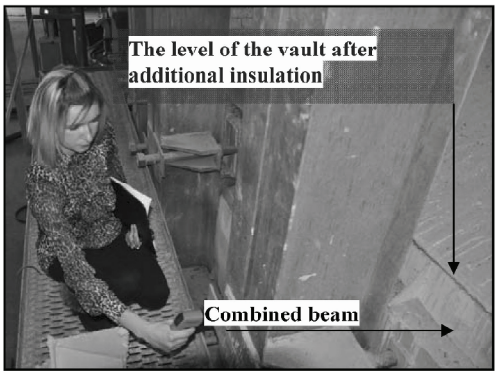
On the basis of the data of table 1, we can draw conclusions about the change in temperature on the surface of the column furnace binding, assuming that:

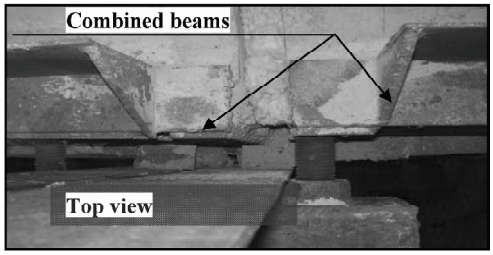
– reduce the temperature in the section «A» is connected with additional warming of the arch refractory bricks used in a range of temperatures from 900 °C to 1300 °C, apparent density of 0.4 to 1.4 g/cm^3, the average thermal conductivity 0.25 W/m · K additional linear shrinkage at shutter speeds of 2 hours, not more than 1.0–2.0 %. The temperature of the outer contour of the arch of the furnace at the moment amounted to 135 °C, which is almost 2 times less than the temperature in 2009. The additional insulation on the vault can be traced through the pictures in the figure 1. Them clearly shows the excess of the masonry above the level of the combined beam. The temperature rise in the section «A» due to a change in the temperature regime in the unit the furnace. If the introduction of the furnace into operation the maximum temperature was +1480 °C, at the time of this survey is +1548 °C. Data temperature in the furnace are read from a mnemonic displayed by using the licensed software package Siemens PCS 7, (full name: SIEMENS SIMATIC Process Control System 7).

Table 1. Temperatures change loft columns

Year	Sketch	Section A	Section B	Section C
September 2009		82.2 °C T2 T1 66.5 °C	72.05 °C T4 T3 52.15 °C	139.45 °C T6 T5 77.8 °C
October 2013		77 °C T2 73 °C T1 65 °C	85 °C T4 80 °C T3 69 °C	82 °C T6 T5 67 °C
Δt		-5.2 °C T2 T1 -1.5 °C	12.95 °C T4 T3 16.85 °C	-57.45 °C T6 T5 -10.8 °C







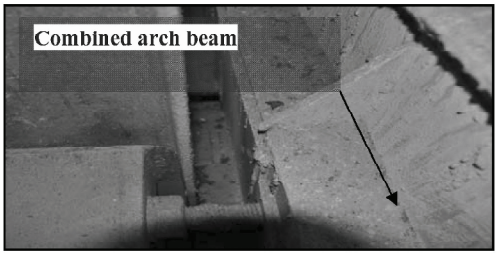


Figure 1. Change the design of the arch of the furnace: a) the state of the arch in 2009, b) the state of the arch in 2013.

It is a set of programs for creation of the automated control systems of technological processes, fully complying with the requirements of the concept of «totally integrated automation». Consideration of the mimic will be given and discussed below.

– section «C» is under construction supporting walls of gas-flame furnace, controlled point KZT6, in turn, is on the side walls of the pool, where there is a melting glass. A drop in temperatures in the section «C», at the point of T6 on 57.45 °C is explained by several factors. The fact is that, at the time of first inspection of the furnace in a working condition were installed not all elements of the system of air cooling wall cooking pool, this can be seen in figure 2a. In addition to the lack of cooling elements, directly near the studied column, there was a gap between the oval-flatten and the wall of the brewing basin virtually around the perimeter of the furnace (figure 2b).

At this point of time the walls of cooking and flame space isolated additional layer of hard refractory high-temperature slab insulation, thick 2.5 cm. It has a density of 300 kg/m^3, coefficient of heat conductivity varies from 0.10–0.21 W/m× K in the temperature dependence of the application.

Changes in the lining of the furnace can be seen in figure 3.

The done events significantly influenced the surface temperature of frame columns of the furnace binding.

To study the interesting questions, concerning the current processes in the Assembly of the furnace, which might even indirectly influence the change of the VAT columns strapping in time, were tracked indications in periods of alternate mode of operation of the regenerators. To study the processes taking place in the space of the unit the furnace had previously studied in the literature [11–15]. The presence of two variations helped to compare the change of numerical parameters of technological

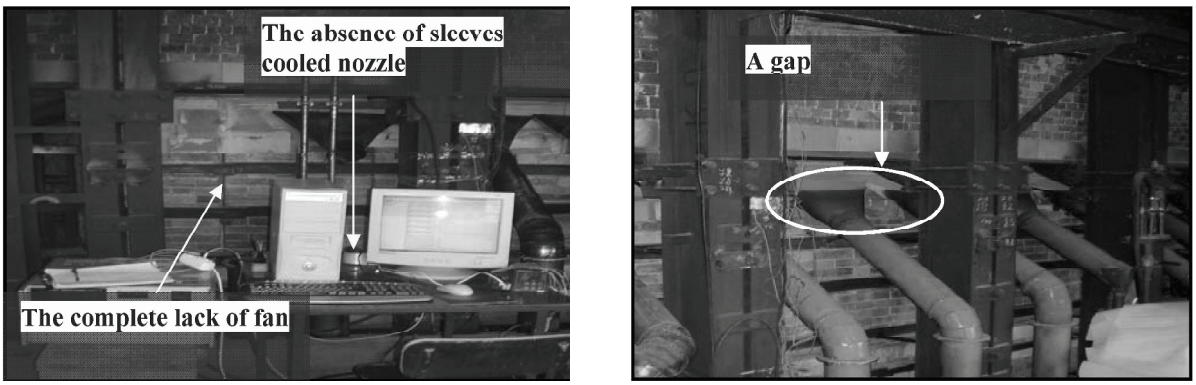


Figure 2. Cooling system faults and insulation of refractory lining of the furnace: a) not all elements of the system of air cooling wall cooking pool, b) the wall of the brewing basin virtually around the perimeter of the furnace.

Figure 3. Insulation of walls cooking basin: a) insulation of walls cooking basin in 2009, b) insulation of walls cooking basin in 2013.

process. In figure 4 illustrates the work of the furnace during the application period flame on the left, the change of the flow flame occurs every 20 min.

On the basis of the data of mnemonic can be traced temperature difference flame space and temperature in the pool, track temperature differences depending on the direction of the flame and the length of the oven (figure 5).

Temperature difference in oxy-space and in the basin of the furnace, at different positions of the filing

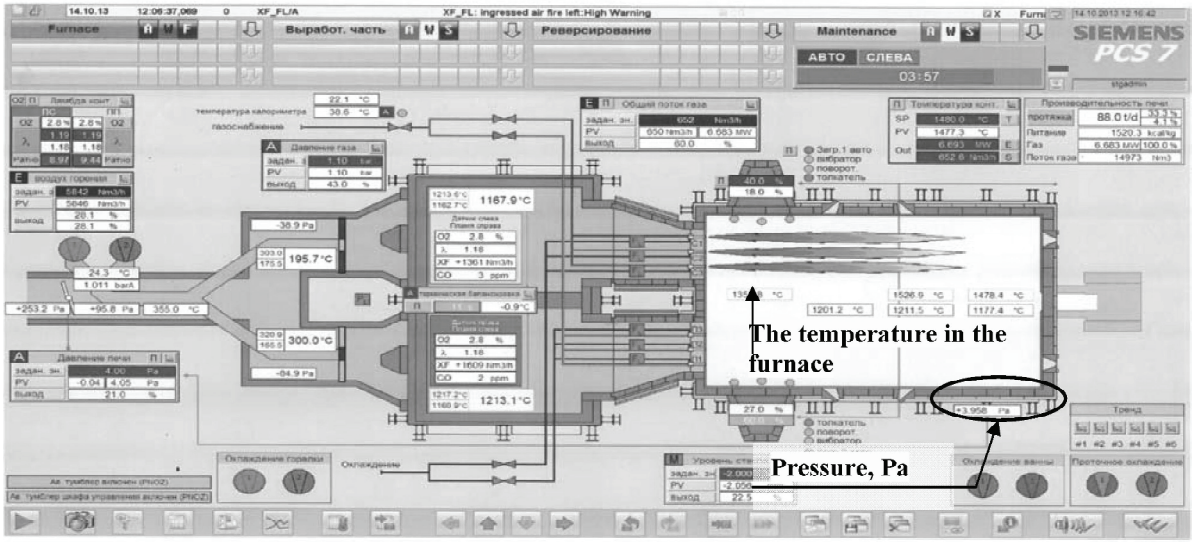


Figure 4. The mnemonic of work of the furnace during the application period flame on the left.

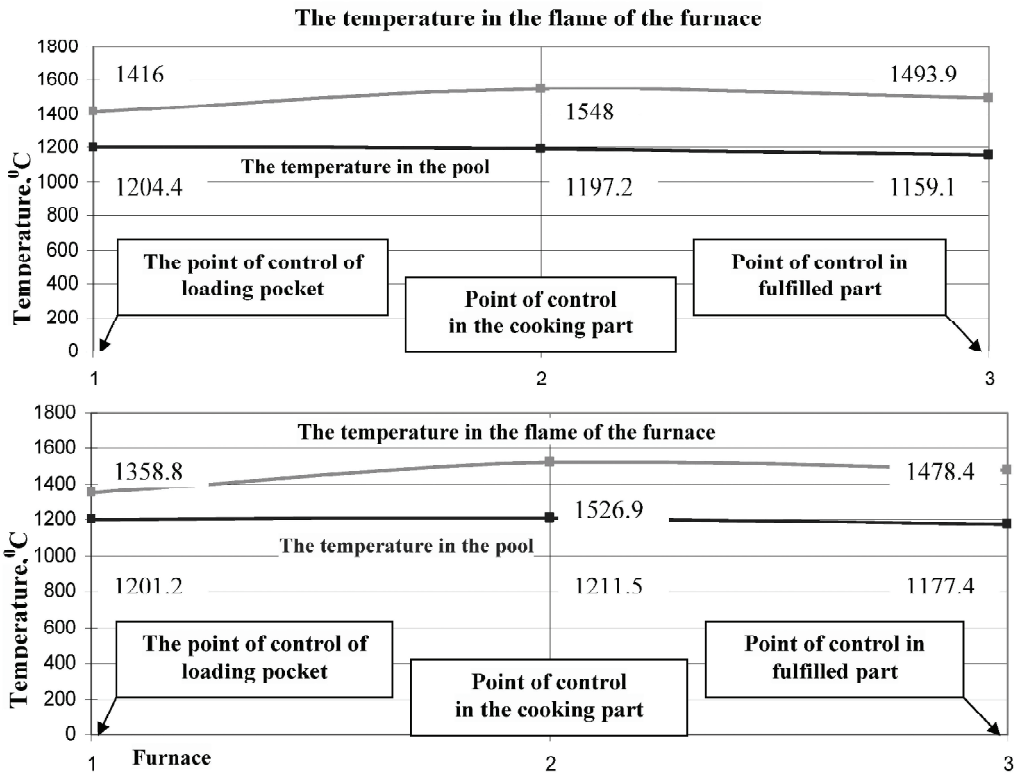


Figure 5. A graph of the temperature distribution in the furnace when submitting: a) a graph of the temperature distribution in the furnace when submitting the flame on the right, b) a graph of the temperature distribution in the furnace when submitting the flame on the left.

of the flame is not significant, and will not affect the frame columns strapping can be neglected in subsequent calculations. The temperature in the flame of the furnace exceeds the temperature in the basin of the furnace, the maximum in the cooking of the 350 °C and in the fulfilled – on 330 °C, in the loading pocket the difference is about 200 °C (figure 5). The data obtained by changes in temperature height of the unit the furnace will be included in the calculations to determine the actual work of the metal frame of the furnace.

Gas pressure in the working chamber of the furnace are measured at the end of the cooking part, because here it less varies and there is no impact of a flame. For pressure measurement in suspension walls on both sides of the furnace are gassing tube 5, which are connected with a common pipeline to get an average pressure.

The advantage of controlling complex Siemens PCS 7 is the ability to view data for any time interval. Use this function to program were tracked changes flows of gas pressure in the space of the furnace and in time. Archived settings are stored from the start and never removed from the system, that has allowed to conduct the analysis of gassing environment.

For clarity, the process displays information with 6.15 until 12.00 14.10.13. The diagram (figure 7) shows that the overwhelming pressure in the furnace is around +4.00 to –1.00 Pa, vacuum gas is generated every 20 min.

To maintain stable conditions glass melting gas atmosphere in the furnace should be constant. Change of the composition or the pressure of flue gases, can have a significant impact on the quality of the glass. At the time of the survey, deformation of the metal frame of the furnace is not detected.

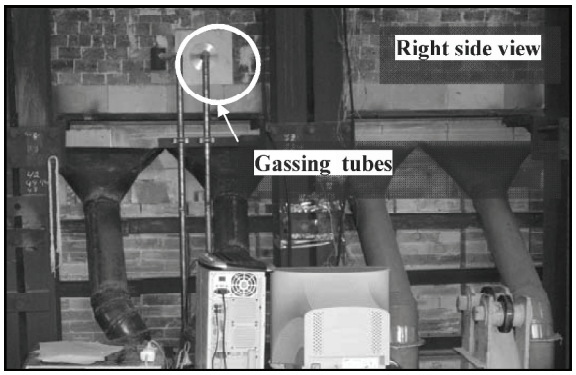


Figure 6. Location of gaseous pipelines on both sides of the furnace.

Conclusions

It is very difficult to trace the concept of changing any parameters during the operation of the furnace with a margin of technological process flowing in it and a complex of measures for its service to create the conditions for proper functioning. The analytical way, on the basis of instrumental and visual control, automated control systems of technological

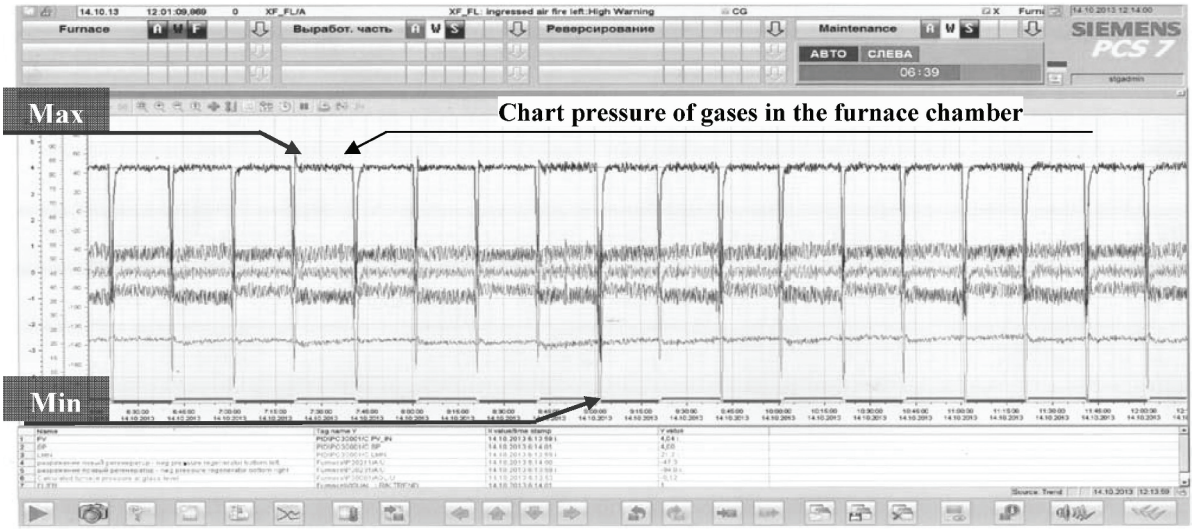


Figure 7. Chart of gas pressure in the unit the furnace.

processes and systematization of data you can find a rational explanation of changing parameters.

Found the explanation of temperature changes columns loft:

– reduce the temperature in the section «A» is connected with additional warming vault; the temperature rise in the section «A» due to a change in the temperature regime in the unit the furnace by means of thermal conductivity;
– reduce the temperature in the section «With» affected adjustment of the system of air cooling wall cooking pool, additional insulation of walls and eliminating gaps and sealing of seams of a laying, also influenced by the factor of glass in the pool of the furnace, because in the period of early research 2009 he was absent, due to technology broods furnace «dry». You can assume that all of the temperature in the furnace is given to the walls and the vault, for lack of glass in the pool. On this basis it is possible to draw a conclusion about the distribution of temperature with height of the furnace, the average temperature difference in oxy-space and in the basin of the furnace difference in average 300 °C.

In further calculations will be made to adjust to changing temperatures height, loft, and as additional load caused by service of the furnace during the period of its operation, to improve technological process of isolation of the code.

On the basis of the data of mnemonic diagrams of work of the furnace and archival data management program, revealed a slight drop of temperature in the period of interleaving the filing of a torch, and a slight pressure generated cooking gases. These values are negligible, and in the analytical model can be neglected.

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