Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 153 (2016) 509 – 512

Procedia Engineering

www.elsevier.com/locate/procedia

XXV Polish – Russian – Slovak Seminar “Theoretical Foundation of Civil Engineering”

Comparative analysis of dynamic characteristics of the model of the auger extruder control system with the results of field experiments

Maxim A.Nazarov[a]*, Victor I.Kichigin[a], Alexander S.Fadeev[a]

[a] *Samara State University of Architecture and Civil Engineering, Molodogvardeyskaya St, 194, Samara, 443001, Russia*

Abstract

Authors present the description of the experimental plant based on the auger vacuum extruder at the enterprise for brick production and designed to assess the adequacy of the developed mathematical model of the process of the plastic shaping of the ceramic mixture. The main difficulty in carrying out the comparative analysis is that the shear rate of the ceramic mixture in the extruder pressure head has been taken for the basic output coordinate of the created model. It most fully characterizes the shaping process focused on the production of brick of specified durability. There is no possibility to measure directly on the production unit. To overcome this problem in the structure of the shaping process model pressure of the ceramic mixture behind the extruder protruding blade has been chosen as an additional coordinate. The technique of carrying out experiments is given. Comparison of transient formation pressure obtained on the operating plant and on the model has been made. It is established that their divergence has made 5.2 % and that confirms the adequacy of the mathematical model for the ceramic mixture shaping in the auger vacuum extruder.

Peer-review under responsibility of the organizing committee of the XXV Polish – Russian – Slovak Seminar “Theoretical Foundation of Civil Engineering”.

*Keywords:*auger vacuum extruder; ceramic mixture; brick; control system; experimental plant; mathematical model.

---

1. Problem formulation

At brick making plants the biggest share of the production bad quality largely because of the transient process of the ceramic mixture shaping is observed. Changes of humidity, temperature, index of the ceramic mixture flow and

---

* Corresponding author. Tel.: +7-917-142-28-93.
*E-mail address:*nazarovm86@yandex.ru

Peer-review under responsibility of the organizing committee of the XXV Polish – Russian – Slovak Seminar “Theoretical Foundation of Civil Engineering”.
doi:10.1016/j.proeng.2016.08.171

draft intensity in the extruder vacuum chamber are reasons of the formed brick parameter variation. The authors show[1-6] the possibility to solve this problem using modern automatic control systems which differ from known ones in the fact while controlling the shaping process information on the output shear rate $\dot{\gamma}$ of the ceramic mixture is used in them. Creation of these control systems needs developing the mathematical model of the shaping process as an object of control and subsequent assessment of its adequacy. The aim of the research is to assess the adequacy of the proposed mathematical [7-11] and computation [12] models of the shaping process by comparing their dynamic characteristics with those of the control system of the production auger extruder.

The problem is that it is impossible to measure the shear rate $\dot{\gamma}$ on the operating equipment. Paying attention to the fact that in the developed model a mathematical relationship between $\dot{\gamma}$ and pressure P of the ceramic mixture behind the protruding blade of the extruder has been established, we believe it rational to carry out the adequacy assessment by comparing dynamic characteristics of pressure P_m on the model and P_{pl} on the experimental plant.

2. Experimental plant

Experimental plant is the equipment complex (Fig. 1, a) including an auger vacuum extruder (1) with a pressure head (2); a frequency inverter (3); solenoid steam metering valve (4); a microprocessor-based system (5) for pressure automatic control in the element 2, including an solenoid water metering valve (6), a pressure sensor (7), a programmable logic controller PLC (8) in which the set point is implemented (9), a comparator (10), a controller (11), a pulse-width modulator (12), SCADA-system (13).

3. Mathematical model

In the structure (Fig. 1, b) of plastic shaping as an object of control the shear rate $\dot{\gamma}$, the brick strength R after drying and firing, pressure P_m of the mixture in the pressure head have been chosen as output coordinates. Input actions are: frequency ω_{01} of voltage supplying the extruder power motor, pressureP_v in the vacuum chamber, flow index ψ and moisture content w of the ceramic mixture.

In the production plant pressure P of the ceramic mixture behind the protruding blade of the extruder is controlled by adding some additional water into the mixer. The similar method of controlling is also applied in the mathematical model. The control unit includes a pressure controller C (Fig.1, b), a solenoid valve SV to control the additional water flow rate into the mixer Q, a pressure sensor PS and a pulse-width modulator PWM to provide a controller C-to-valve SV interface.

4. Testing procedure

Comparison of the model with the production plant has been made by means of matching time-pressure characteristics P_{pl} (Fig. 2, curve1) and P_m (Fig. 2, curve 2) as reactions to similar change of demand signals on the model and plant.

Researches were conducted without stopping production. The initial pressure in the pressure head was $P_{pl.0} = 1.7\ MPa$ at the time moment $t = 1000\ s$ the system reference signal P_r (Fig. 2, curve 3) was reduced in steps up to $1.5\ MPa$. This resulted in the change of pressure P_{pl}. The similar signal was also given on the model of the system (fig. 1, b). Comparison of curves was carried out in block 14 (Fig. 1).

From comparison of these characteristics it follows that the nature of the model process generally coincides with the process on the operating equipment. It is established that the transient process time on the model is $t_m = 370\ s$ whereas on the plant $t_{pl} = 320\ s$; the overshoot value is 6 and $6.5\ \%$ respectively. The curve mean squared deviation value is $5.2\ \%$. Therefore, it is possible to deduce that the developed mathematical model is quite adequate and maybe used at synthesis of a new class of control systems for the auger extruder.