Available online at http://www.journalijdr.com

IJDR

ISSN: 2230-9926

International Journal of Development Research
Vol. 07, Issue, 09, pp.15602-15604, September, 2017

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

DEFINITION OF LYAPUNOV INDEX OF DEHYDRATION PROCESS AND GRANULATION IN A FLUIDISED BED

[*,1]Dr. Habil. Bogdan Korniyenko, [2]Valery Oliynyk and [2]Dr. Lesia Ladieva

[1]Department of Computerized Information Security Systems, National Aviation University, Kyiv, Ukraine
[2]Department of Automation of Chemical Production, Engineering and Chemical Faculty, National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine

ARTICLE INFO

Article History:

Received 08th June, 2017
Received in revised form
29th July, 2017
Accepted 14th August, 2017
Published online 30th September, 2017

Keywords:

Fluidized bed, Granulation, Dehydration, Mineral fertilizers, Chaotic motion, Two-phase system, Attractor, Lyapunov index.

ABSTRACT

Investigation of nonlinear mathematical model of the process of dehydration and granulation in a fluidised bed was made. Mathematical model for two-dimensional systems in variations was obtained. It was considered control actions: flow rate and cost solution. It was built an attractor for a dissipative dynamic system that represents the nature of limit cycle in phase plane. It was believed that the cost of gas depends on the temperature and subject to harmonic law. It was calculated senior Lyapunov index by changing the initial conditions. The trajectories diverge that led to the conclusion for the chaotic flow of traffic phases. Chaotic behavior is desirable for dewatering and granulation process, as enhances the mixing process.

***Corresponding author**

Citation: Dr. Habil. Bogdan Korniyenko, Valery Oliynyk and Dr. Lesia Ladieva. 2017. "Definition of lyapunov index of dehydration process and granulation in a fluidised bed", *International Journal of Development Research*, 7, (09), 15602-15604.

INTRODUCTION

Mineral fertilizers are a source of various nutrients for plants, first of all nitrogen, phosphorus and potassium, and calcium, magnesium, sulfur, iron. All these elements belong to the group of macronutrients because they are absorbed by plants in large amounts. In the complete absence of any element in the soil plant cannot grow and develop normally. From environmental, technological and economic points of view, it is advisable to obtain fertilizer in the form of pellets. Efficiency of granulation depends on the granulation mechanism, which is determined by the implementation process. In this paper we studied management system of process dehydration and granulation in a fluidised bed in order to intensify heat and mass transfer processes and improving the quality of fertilizer granules. Fluidization is a way of interaction of gas flow or liquid (liquefaction agent) with a layer of solid granular material when solid particles suspended in the flow, have a fluctuation or rotational motion within the layer. The transition of fixed bed to fluidized occurs at such speed of fluidizing agent (the first critical speed), that provides a balance between the forces of gravity and traction on the one hand, and the aerodynamic force of flow on the other. Fluidized bed exists in a range of speeds, the upper limit of which is the second critical speed. In this solid particles begin to carry out from a layer of liquid agent. Depending on the flow velocity the fluidized bed is in one of the following conditions: filtration, loosening, "boiling" regime removal. Such division is conditional, since the existence of the limit condition depends on the size, shape and density of solids, and the properties of the fluidizing agent. Fluidization widely used in industrial technology, since the use of fluidized bed leads to increased efficiency of heat and mass transfer due to mixing. There were a large number of studies on the granulation process organic fertilizers in a fluidised bed. It was developed some mathematical models of the processes of dehydration and granulation. There are several approaches to mathematical modeling of these processes. Specifically it was used mathematical models of two-phase flow [Davidson and

Harrison, 1973; Horio and Wen, 1977; Grace, 1986; Kuny and Levenshpil, 1976; Stringer, 1989; Kuipers et al., 1998; Korniyenko, 2011; Korniyenko, 2012; Korniyenko, 2012; Korniyenko, 2013; Korniyenko, 2013; Korniyenko, 2013; Korniyenko, 2014]. Granular material in a fluidized bed system is chaotic. When the process of fertilizer granulation unit in the fluidized bed was investigated, it has been hypothesized that the formation of granules is chaotic and deterministic process. It was investigated temporal characteristics of the pressure drop in gas distribution grid for the different diameters of granules with different numbers fluidization and determined signal range. To confirm the assumption of the existence of deterministic chaos we studied Kolmogorov entropy. Kolmogorov Entropy is an important common characteristic of nonlinear dynamic systems and characterizes the degree of disorder of the system as a whole and is proportional to the speed of data loss. It was received the Kolmogorov entropy numerical values in a range 3,1-4,6 bit/s. Experimental studies have confirmed that local areas of concentration and pressure cavities have a random fluctuations associated with nonlinear dynamics [Kuznecov, 2006; Korniyenko et al., 2013]. Therefore, using the chaos can describe the dynamics of the fluidized bed and study processes in the machine for different hydrodynamic regimes. Deterministic chaos can occur in a fluidized bed as a result of nonlinear interaction of bubbles of gas.

METHODS

In the study of nonlinear systems an important task is to determine the type fluctuations - periodic, quasi-periodic, random, chaotic. Particularly difficult to distinguish quasi-periodic oscillations of chaotic and random, as quasi-periodic oscillations often have very complex shape, visually not differ from the "random". The peculiarity of chaotic oscillations is their high sensitivity to small changes in initial conditions. Therefore, one of the most reliable ways to determine the chaos is to determine the rate of recession trajectories as measured using Lyapunov exponents. Signs Lyapunov indicators fully characterize the type of oscillation dynamical system solutions. The presence of positive indicator is the criterion chaotic dynamical system solutions. Lyapunov indicators determined for a given "reference" trajectory $x(t)=x_0$. Equation in variations composed for this (linearized system in the neighborhood x(t)). Mathematical model of dehydration and granulation in a fluidised bed represented as:

$$\frac{dx}{dt} = -b_1 \cdot G_f \cdot x - a_{11} \cdot x - a_{12} \cdot y \; ; \qquad (1)$$

$$\frac{dy}{dt} = b_2 \cdot G_p \cdot y + a_{21} \cdot x - a_{22} \cdot y + a_{23} \frac{y}{x} \; , \qquad (2)$$

where x,y – in accordance with the coolant temperature and fluidized bed, G_f – flow rate, kg/s, G_p – expense solution, kg/s.

It was conducted research system. Fixed values of variables:

$$X_s = \frac{a_{23}}{-b_2 \cdot G_p + a_{22}}; \; y_s = \frac{\left(b_1 \cdot G_f + a_{11}\right) \cdot a_{23}}{\left(-b_2 \cdot G_p + a_{22}\right) \cdot a_{12}}, \qquad (3)$$

where ξ, ŋ – deviation from the fixed value. It was maked as:

$$f(x, y) = -b_1 \cdot G_f \cdot x - a_{11} \cdot x - a_{12} \cdot y \; ; \qquad (4)$$

$$g(x, y) = b_2 \cdot G_p \cdot y + a_{21} \cdot x - a_{22} \cdot y + a_{23} \cdot \frac{y}{x} \; . \qquad (5)$$

Then, using the expansion in Taylor we received:

$$\frac{d\P}{dt} = f'_x(\mathrm{x,y}) \cdot \P + f'_y(\mathrm{x,y}) \cdot \text{¦} = -(b_1 \cdot G_f + a_{11}) \cdot \P + a_{12} \cdot \text{¦} \; ;$$
(6)

$$\frac{d\text{¦}}{dt} = g'_x(x,y) \cdot \P + g'_y(x,y) \cdot \text{¦} = \left[a_{21} - \frac{(b_1 \cdot G_f + a_{11}) \cdot (-b_2 \cdot G_p + a_{22})}{a_{12}} \right] \cdot \P + \qquad (7)$$
$$+(b_2 \cdot G_p - a_{22}) \cdot \text{¦}$$

Mathematical image mode of operation dissipative dynamic system is an attractor - boundary trajectory of point that depicts phase space to which all aspire output modes. If this mode is a steady state of equilibrium - attractor system is a fixed point if it is stable periodic motion - be shut attractor curve, called the limit cycle. For deterministic chaos attractor has two significant features: non-recurrent trajectory of the attractor (it closed) and mode of operation is unstable (small deviations from the regime increases). Fig. 1 presents attractor obtained for the system (1)-(2). By nature he is limit cycle in phase plane. The instability of equilibrium in a two-dimensional nonlinear system generates stable oscillation mode. This attractor is typical only for the auto oscillatory systems, the dimension of which more than two.

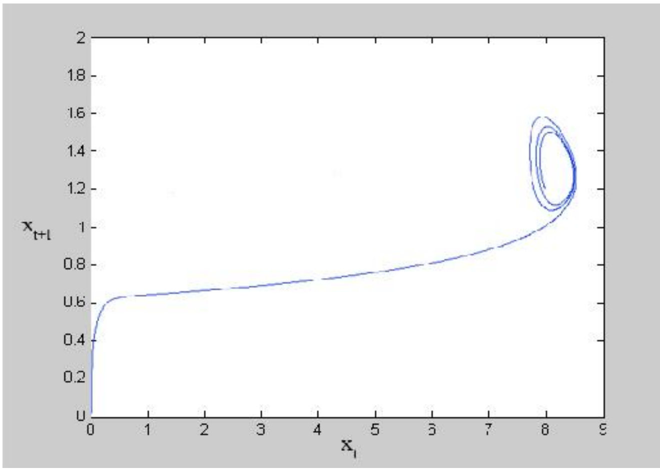

Fig. 1. The attractor for system (1) - (2)

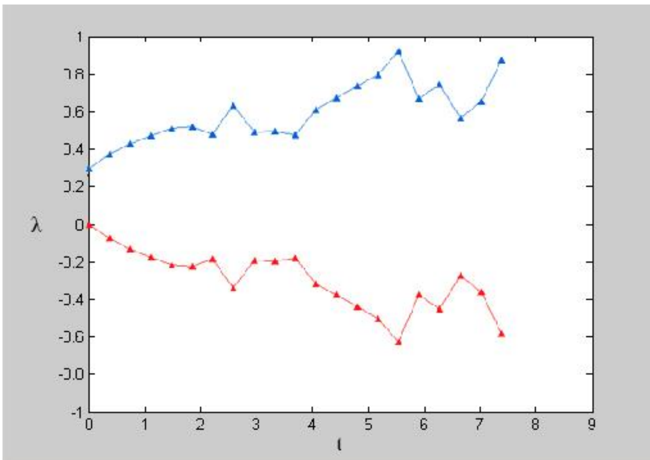

Fig. 2. Senior Lyapunov index by changing the initial conditions

It was believed that the expense of gas depends on the temperature and subject to harmonic law. Analytical determination of the Lyapunov indicators may be quite rare, but using numerical methods can be calculated with acceptable accuracy, particularly through Benettyna algorithm. The Fig. 2 presented senior Lyapunov index by changing the initial conditions. The graph shows that the divergent path that leads to the conclusion for the chaotic flow of traffic phases.

Conclusion

At first glance, the nature of chaos precludes manage it. In fact, the situation is exactly the opposite: instability of the trajectories of chaotic systems makes them extremely sensitive to control. For the process of dehydration and granulation in a fluidised bed chaotic behavior is desirable because it enhances the mixing process, which is important for the fluidized bed. This results in reducing gas bubbles, which in turn improves the mass transfer. It is necessary to develop a process control system to improve the speed of mixing chaotic flux pellets of liquid and gas bubbles, which will be based on increasing the degree of mixing.

REFERENCES

Davidson, J. and Harrison, D. 1973. *Psevdoogigenie.* M.: Chimija.

Grace, J.R. 1986. *Fluidized Beds as Chemical Reactors, in Gas Fluidization Technology*. John Wiley & Sons, Chichester, New York, Brisbane, Toronto, Singapore.

Horio, M. and Wen, C.Y. 1977. An Assessment of Fluidized-Bed Modeling. *AIChE Symp. Ser.*, Vol. 73, No. 161, pp. 9-21.

Korniyenko, B. 2011. Osoblyvosti modeljuvannja procesiv perenosu u dyspersnyh systemah. *Visnyk Nacional'nogo tehnichnogo universytetu Ukrai'ny «Kyi'vs'kyj politehnichnyj instytut», Serija «Himichna inzhenerija, ekologija ta resursozberezhennja»*, № 2(8) pp. 5-9.

Korniyenko, B. 2012. Dynamika procesiv znevodnennja ta granuljuvannja u psevdozridzhenomu shari. *Visnyk Nacional'nogo tehnichnogo universytetu Ukrai'ny «Kyi'vs'kyj politehnichnyj instytut», Serija «Himichna inzhenerija, ekologija ta resursozberezhennja»*, № 1(9) pp. 15-19.

Korniyenko, B. 2012. Matematychne modeljuvannja dynamiky procesiv perenosu pry znevodnenni ta granuljuvanni u psevdozridzhenomu shari. *Visnyk Nacional'nogo aviacijnogo universytetu*, № 4(53) pp. 84 - 90.

Korniyenko, B. 2013. Research modes of a fluidized bed granulator. *The Advanced Science Journal*, (5) pp. 12 - 15.

Korniyenko, B. 2013. Static and dynamic characteristics of transport processes in disperse systems. *Naukojemni tehnologii'*, № 2 (18) pp. 166 - 170.

Korniyenko, B. 2013. The two phase model of formation of mineral fertilizers in the fluidized-bed granulator. *The Advanced Science Journal*, (4) pp. 41 - 44.

Korniyenko, B. 2014. *Informacijni tehnologii' optymal'nogo upravlinnja vyrobnyctvom mineral'nyh dobryv*. K.: Vyd-vo Agrar Media Grup.

Korniyenko, B., Ladieva L. and Snigur O. 2013 Granuljuvannja u psevdozridzhenomu shari. Doslidzhennja determinovanogo haosu procesu. *Himichna promyslovist' Ukrai'ny*, № 2 pp. 20 -23.

Kuipers, J.A.M., Hoomans, B.P.B. and van Swaaij, W.P.M. 1998. Hydrodynamic Models of Gas-fluidized Beds and Their Role for Design and Operation of Fluidized Bed Chemical Reactors . *Fluidization IX, L.-S. Fan and T.M. Knowlton (Eds.), Engineering Foundation, New York*, pp. 15-30.

Kuny, D. and Levenshpil, O. 1976. *Promishlennoe psevdoogigenie*. M.: Chimija.

Kuznecov, S.P. 2006. *Dynamycheskyj haos*. M.:Fyzmatlyt.

Stringer, J. 1989. Is a Fluidized Bed a Chaotic Dynamic System. *10th Int. Conf. on Fluidized Bed Combustion, ASME , New York, USA*, pp. 265-272.

****