CHAOTIC ANALYSIS OF THERMAL CONVECTION LOOP

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ABSTRACT
Chaos and chaotic systems have many fields of applications. This paper discusses chaos analysis of the three dimensional thermal convection system. Chaotic signals depend very sensitively on initial conditions.Some basic dynamical behaviors and the dynamical structure of the this chaotic system are investigated numerically.

Keywords: Thermal convection loop attractor, chaos, stability,

1. INTRODUCTION:
Chaos is not randomness, but a concept that has an order. One of the first steps for the chaotic analysis of a signal that shows change in time is usually to acquire the appearance of the system’s behavior in phase space.Chaos is defined as an aperiodic long-time behavior arising in a deterministic dynamical system that exhibits a sensitive dependence on initial conditions [1].The loop provides an appropriate platform for reading, evaluating and comparing various control strategies. Firstly in experimental and theoretic researches, Singer, Wang and Bau [2-4], linear and non-linear control strategies are used for changing convective movement bifurcation mold in a thermal convection loop[5]

This process, which requires a range of complex calculation, can be easily carried out with the help of the computers. In software like MATLAB, there are ready macros and algorithms available for such process. Entropic irregularity sometimes is mixed with chaos that means ‘disruption, tumult and uncertainty. Physically meaning irregularity, Entropic Irregularity, shortly, can be defined in two ways that integrate each other, firstly, The diffusion of a specific system’s total energy among the available pieces, secondly, In a thermal process, as a result of lack in transforming the total energy into useful mechanical work that enters to the system, the system can’t renew itself with the useful mechanical work acquired by turning back and therefore, the system can’t rehabilitate by itself. Lorenz system [6], which is defined as a chaotic system in literature, was thought as a model for the 2D fluid convection by E. Lorenz approximately 30 years ago. This 3rd degree nonlinear chaotic system is defined with the equation team below. This system has become a system that many researchers work on it for years. As it is seen in the equations, this chaotic system is a 3rd degree system that the nonlinearity provided by linear multiplying terms. One of the most important features of a chaotic system is being sensitively connected to the starting conditions. A slight change in the starting conditions may cause a big change of the system response. On the purpose of showing and explaining this feature, Lorenz system has been simulated with the MATLAB program for different starting values. In the sense of complex branching and chaos expositing, Chua circuit has become the model circuit that explains the chaos situation in electricity. Observing in which conditions a system enters a chaos and how, meanwhile, in order to specify changes of flow type and speed, it is determined that we can use Thermal Convection Loop

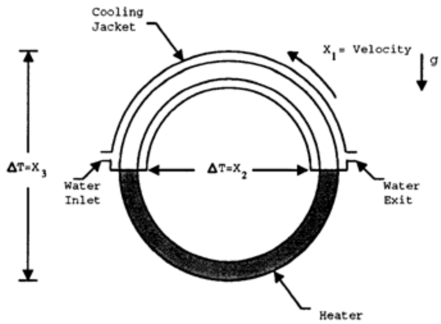

Figure1. Thermal convection loop [5]

In Thermal Convection Loop, difference in horizontal section is symbolized as D_t, difference in vertical section as X_2, and average speed in sequence X_1.It is observed that when we measure temperature differences of horizontal and vertical positions as time function, this heating and cooling temperature values can cause fluid movement in the system. In a system that heated from the bottom (clockwise 3-9 positions) and cooled from the top (clockwise 6-12 positions), chaos can be easily followed. The cooling here is depended on the temperatures and the temperature and heat quantity is inversely proportional. The adjustment of the heater's heating speed is one of the biggest parameters that drag the system into chaos. In low heating speeds like W, the flow is regular, laminar and simplex. Around W the fixed movement loses its determination and the flow becomes ensnarled. Contrary periods are occasionally observed during irregular oscillation. By controlling the system successfully, the flow comes to the state of laminar, the fluctuation comes to an end and the chaos is prevented.

In this experimental system, if small particles are placed in the liquid, direction of the flow and speed profile can be determined by following the positions this particles take depending on temperature differences. It displays that the dynamic behavior is relatively simple experimental set of valuesThe more the heating speed rises, the more the loop flow faces a range of processes like going from inactiveness to a chaotic flow, a movement free from time and bifurcation. For example, with the help of a controller, while naturally composed flow proceeds to a chaotic movement, the flow proceeds from a laminar character to an irregular, jumbled flow. Stabilized sub-critical bifurcation generates super critical bifurcations in stabled periodical orbits which are non-buried chaotic tractive.The analytical model of thermal convection model as follow;

$$
\begin{aligned}
x'_1 &= -px_1 + px_2 \\
x'_2 &= -x_1 x_3 - x_2 \\
x'_3 &= x_1 x_2 - x_3 - R
\end{aligned}
\qquad (1)
$$

Where, $t_0 = 0$, $t_f = 50$, $p = 4$, $R_a = -10$

Using Matlab model of system in Figure 1, phase portraits and time series of system are obtained as shown in Figure 2, and figure 3, respectively.

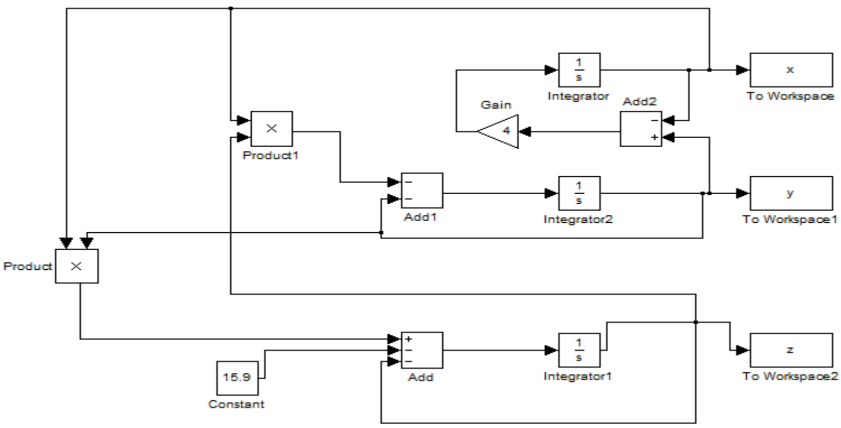

Figure 2. Simulink Model of ThermalConvectionloop

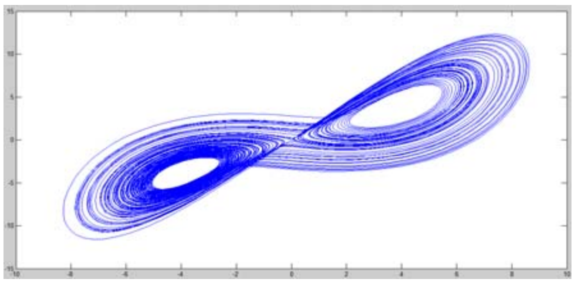

Figure 3. Phase portraits of chaotic attractor

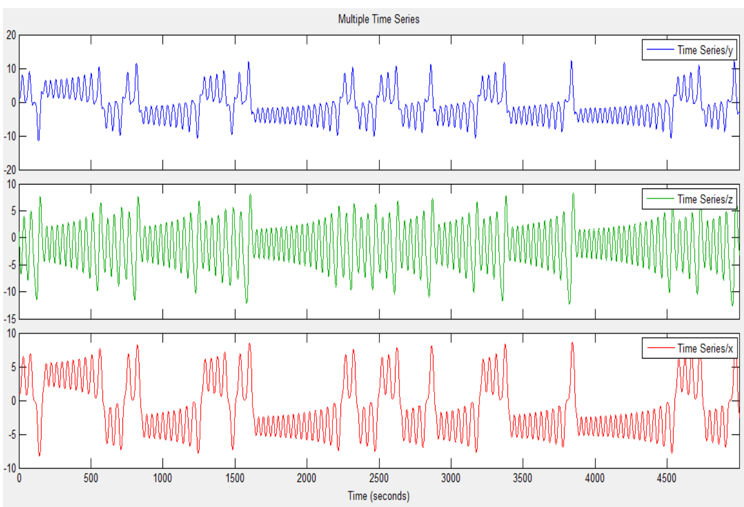

Figure 4. Time series of thermal convection loop

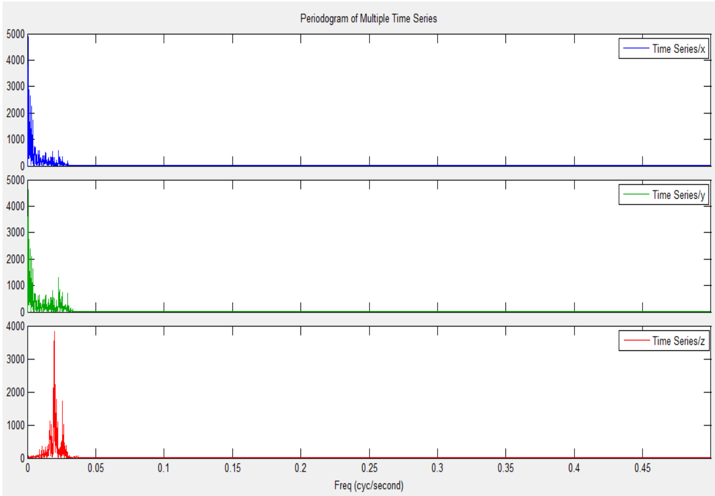

Figure 5. Periodogram of thermal convection loops

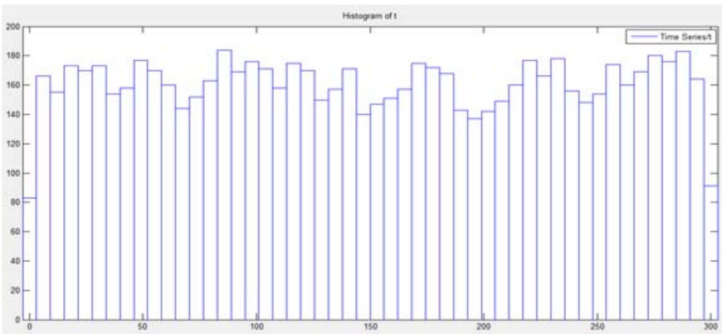

Figure 6. Histogram of thermal convection loops

2. RESULTS

This article introduces one three-dimensional autonomous interesting thermal convection loop chaotic system which can display strange chaotic attractors, time series, periodogram and histogram simultaneously, respectively.Shortly, chaos is a nonlinear science that is defined as irregularity of regularity. The basic feature of chaos and the chaotic signs is that they are extremely sensitive to the starting conditions. The simulation results of thermal convection loop were produced using Matlab program. A good qualitative agreementis illustrated between the simulation results.

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