Study of Chaotic Behavior of Particles by Time Series Analysis by Applying Electric Field to Gas Solid Suspension

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Abstract-The experimental work was carried out in 2D fluidized bed to study chaos under the influence of electric field for the two modes of operation 1)field first and fluidization last and 2) fluidization first and field last. The chaotic parameters were studied by time series analysis In time series analysis a gas velocity of 14 cm/s for 3 cm tap position as well as at 24 cm tap position the fluctuations at V=70 kv shows similar behaviour with field last mode.For the field first mode at ug=14cm/s at V=70 kv and 3 cm tap position the fluctuations are totally diminished where as at 24 cm tap position they still exist.

Keywords-Chaotic Behavoir of particles in the influence of Electric Field

I.INTRODUCTION

The present investigation has been aimed in applying an axial high voltage DC electric field in a two dimensional fluidized bed of semi-insulating glass particles to study the chaos parameter Time series analysis.

II.PROPOSED ALGORITHM

Time Series Analysis (TSA)

Time Series analysis of pressure fluctuations in gas-solid fluidized beds, using techniques from deterministic chaos theory, has revealed that a fluidized bed is a chaotic system that can be characterized with a low dimensional attractor. This makes it possible that the hydrodynamics of fluidization is defined within the context of nonlinear dynamic theory. Pressure fluctuation is one of the most commonly measured parameters in the studies of fluidized beds. Measurements are easy to make requiring a single pressure transducer connected by a small tube to a measurement point in the bed usually a hole in the wall of the column (Brown and Brue, [26]). Many investigators have studied the fluidized bed system by measuring the pressure fluctuations.

Lirag and Litman reported sinusoidal fluctuations for shallow beds and irregular fluctuations with peaks of varying height. These pressure peaks are regularly spaced and the pressure generally decreases quiet steeply after passing a peak. Van Wachem et al. reported the pressure fluctuations as chaotic due to the rising bubbles and solid vortices within the bed and also due to the coalescence phenomenon of the bubbles during fluidization. Fan et al. recorded the pressure fluctuations at 0.4m and 0.59m above the distributor and noticed that the two curves do not coincide, the upper curve lags behind the lower one. The lag or delay time is considered the travelling time of bubbles or slugs from the lower tap to the upper tap. Zhan and Rhee studied the effect of electric field in a cylindrical fluidized bed applying a collinear field to the gas flow for particles of Rochelle salt (dia. 500-600μm). They found that for the gas velocity Us > Umf in absence of electric field, the bubbles caused large fluctuations. With the applied field of

E=0.95 kv/cm and E=1.43 kv/cm at u=1.4Umf, the peak to peak pressure fluctuation amplitude decreases to a minimum value when the field was increased from 0.95kv/cm to 1.43 kv/cm.

III.EXPERIMENT AND RESULT

The experimental studies were carried out in a two dimensional unit (Fig. 1) with a width of 20 cm, depth of 1.5 cm and height of 60 cm. Experiments were carried out in presence and absence of electric field for a bed height of 22cm of settled bed. The fluidizing particles of 275 micron glass beads were used and the fluidizing gas was air. The voltage of 20kv, 40kv, 55kv and 70kv were used in the present studies. The pressure fluctuations at 3cm and 22 cm were measured by absolute pressure transducer. A fine mesh screen (10 micron) was attached to one end of the tube placed at the sampling point to avoid the solids penetration in the transducers thereby avoiding their obstructions. The magnitude of pressure fluctuations from the transducers were observed in a data acquisition system and finally stored in a storage oscilloscope. The numbers of points in one slot were 2500 and such 12500 points were taken for one time series analysis. For statistical and spectral analysis the packages used are MATLAB AND TISEAN and for the chaos analysis the package used is RRCHAOS.

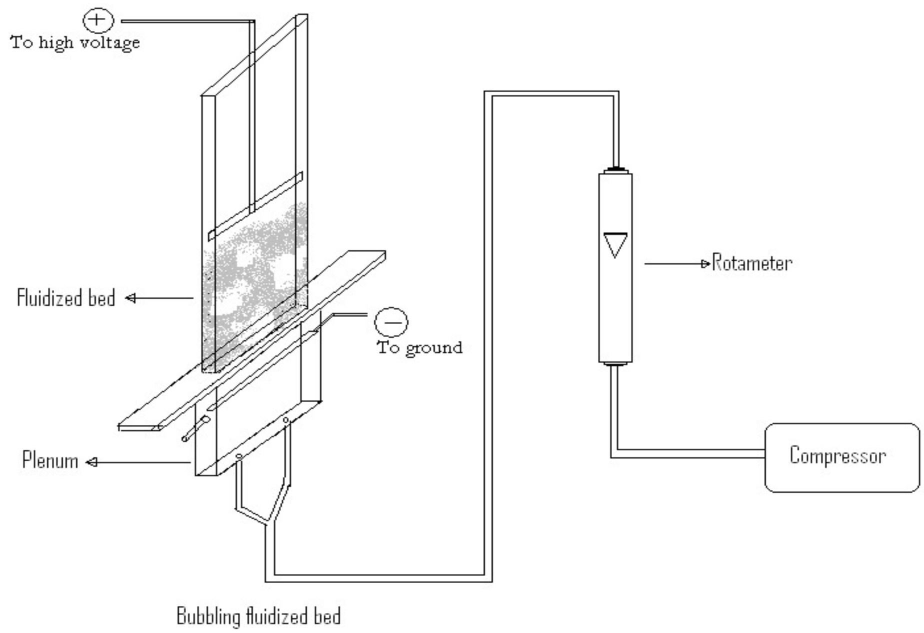


Fig 1:Experimental Set up(2D)

Time series analysis

The nature of the pressure fluctutations in a fluidized bed is a complex function of flowing fluid (gas velocity), tap position, field intensity and the mode of applying the electric field.
Observation in absence of electric field

Effect of gas velocity
Tap position = 3 cm
Fig.1.2.1 and Fig. 1.2.7 shows the pressure fluctuations (PF) without application of electric field recorded at the gas velocity of ug=10 cm/s and ug=14 cm/s respectively. The amplitude of fluctuations increases with the increase in gas velocity. At the higher gas velocity larger bubbles are generated due to increase in coalescence rate and gives larger fluctuations.
Tap position =24 cm
Fig. 1.2.2 (ug=14cm/s) and Fig. 1.2.8 (ug=14cm/s) at 24 cm tapping point shows the slugging behaviour. The amplitude of fluctuations is large. The small bubbles generated near the distributor during their passage through the

bed coalesce, form larger bubbles and break at the surface. The rate of coalescence is greater and these coalesced bubbles burst at the top, hence gives larger fluctuations.

Effect of tap position

Comparison of fluctuations at ug=10 cm/s from Fig. 1.2.1 (3 cm tap position) and Fig.1.2.2 (24 cm tap position) shows that the fluctuation intensity at 24 cm tap position is more. Pressure fluctuation at 3 cm tap position and 24 cm tap position for ug=14 cm/s reported in Fig. 1.2.7 and Fig 1.2.8 shows that the amplitude of pressure fluctuations at 24 cm are more intense.

Effect of voltage

Field First and fluidization last, Ug=10cm/s, Tap position=3 cm

Fig. 1.2.3, 1.2.4, 1.2.5 and 1.2.6 depicts the variation of pressure fluctuations with time recorded at 70 kv for ug=10cm/s for field first and field last respectively. Fig. 1.2.9, 1.2.10, 1.2.11, and 1.2.12 shows the variation of pressure fluctuations with time recorded at 70 kv for ug=14cm/s for field first and field last respectively. As the field intensity increases the interparticle attraction increases and the fluctuation density decreases. The amplitude of oscillations shows the decrease with increase in voltage.

Time Series analysis, Pressure Fluctuations Vs time

Tap position=3cm

Tap position=24cm

(No field**,** ug=14cm/s)

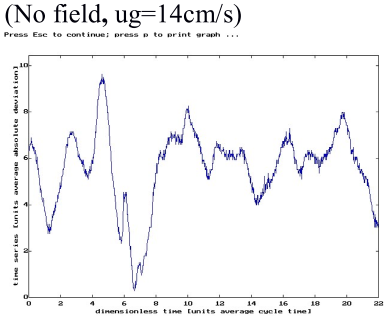


Fig.1.2.1

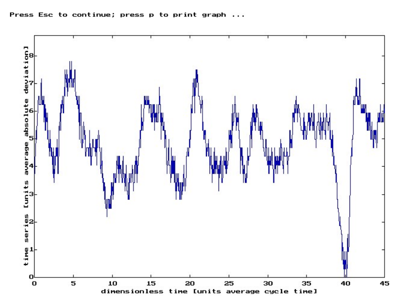


Fig.1.2.2 no field

(Field first fluidization last, ug 10cm/s)

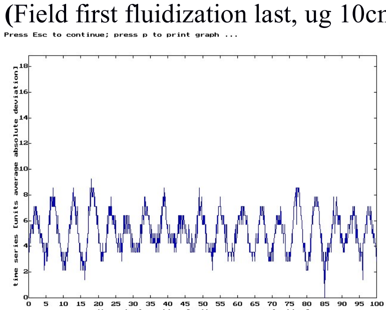


Fig.1.2.3

V=70 kv

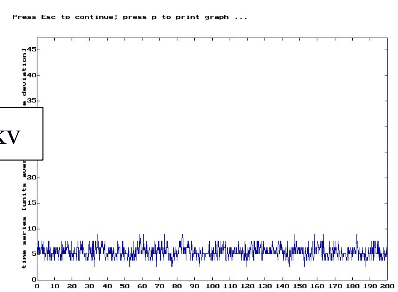
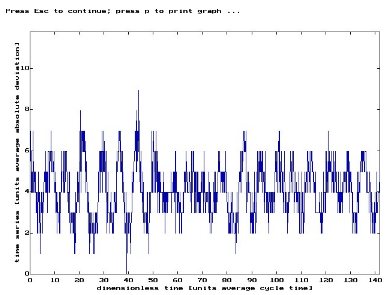


Fig.1.2.4

(Field last fluidization first, ug 10cm/s)



V=70 kv

Fig.1.2.5

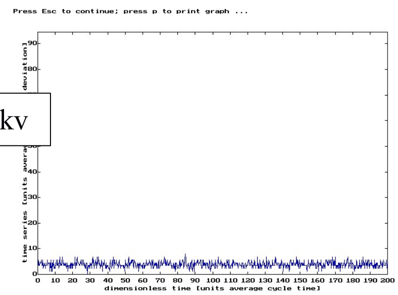


Fig.1.2.6

X axis – time Y axis – pressure fluctuations

Tap position=3cm Tap position=24cm

(No field, ug=14cm/s)

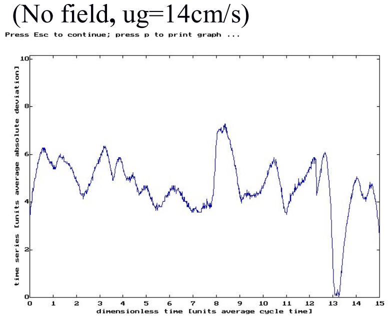


Fig.1.2.7

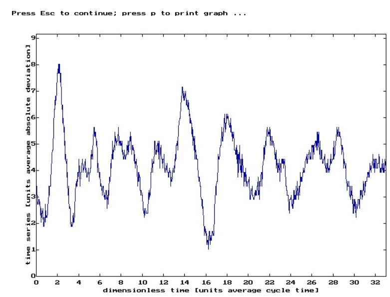


Fig.1.2.8

(Field first fluidization last, ug=14cm/s)

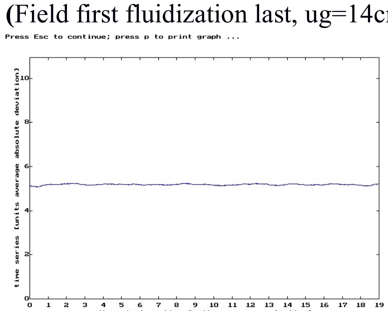


Fig.1.2.9

V=70 kv

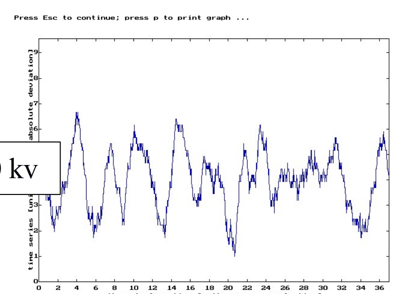


Fig.1.2.10

(Field last fluidization first, ug=14cm/s)

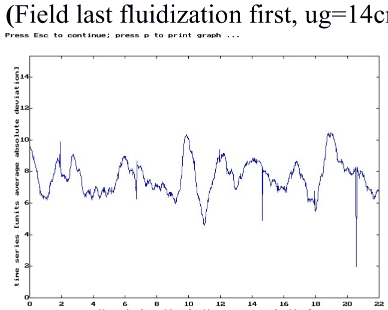


Fig.1.2.11

V=70 kv

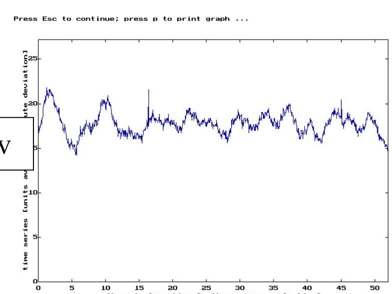


Fig.1.2.12

X axis – time Y axis – pressure fluctuations

IV. CONCLUSION

1) The pressure fluctuations in absence of field at 3 cm tap position are more intense at ug=10cm/s compared to the gas velocity of ug=14 cm/s. However at tap position of 24 cm a similar behaviour is recorded but with the broad spectrum.
2) With the applied voltage of V=70 kv at 3cm tap position the fluctuations are more intensce compared to 24cm tap position for the field first. For field last mode the fluctuations at 3 cm still exist and fluctuations completely die out at 24 cm.
3) At a gas velocity of 14 cm/s for 3 cm tap position as well as at 24 cm tap position the fluctuations at V=70 kv shows similar behaviour with field last mode.
4) For the field first mode at ug=14cm/s at V=70 kv and 3 cm tap position the fluctuations are totally diminished where as at 24 cm tap position they still exist.

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