Simulation of granular in two dimensions: The effect of particle velocity on rigid wall boundary

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Abstract. The various setting of granular systems becomes an interesting and important thing to learn another granular-like system. Each system can represent different physical meaning. In this work, we perform two dimensions simulations of granular on the rigid wall. The varying initial velocities generate for each particle. We used two sets of the rigid wall, straight and inclined wall. The interaction of particle-particle and wall-particles used frictionless rigid body interaction. From the simulation result, observed that the small increment of a given velocity affected the reached maximum height particle as rapidly. The inclined wall indicates the less number of particles that pass through the wall. Future work can implement these results such as on granular energy damping.

1 Introduction

Research on granular characters is widespread as it can represent different physical systems with different initial and different settings. In the previous study, the various simulations were used to analyze granular characteristic in the shear device [1] and about granular packing include package density and any of distribution: contact, coordination number, entropy, and size [2].

Generally, granular studies involve the form of particles of the sphere (3-dimensions) or disk (2-dimension). In this work, we perform granular in 2-dimensions using disk particle as an early study of our research. In advance, several study success to simulate granular in the more complex form [3-4].

The granular simulation is a particles based simulation [5-6]. The arrangement, number, and size of particle allow to describe and analyze various physical phenomena besides discrete properties, such as heat transfer [7], landslide flow [8], and industrial application [9]. The granular analysis can also combine with other methods such as computational fluid dynamics [10].

To get a complete and thorough meaning of the interaction on this granular simulation, we begin by analyzing the effect of particle velocity on rigid wall boundary in 2-dimensions granular simulations. The result of this work used for setting parameters in the future work.

2 Methods

In this simulation, the initial velocity of all the particles is equal, so just before the interaction of the collision, the value of the initial momentum is equal. The direction of the momentum vector is random, as illustrated in Figures 1a and 1b.

Fig. 1a. Illustration of generating momentum for each particle.

Fig. 1b. Illustration of particle-wall interaction.

The granular particles regarded as hard-spheres by imposing momentum conservation [11]. Collisions and interactions are considered to be elastic. Changes in momentum over a given time interval produce contact forces. From this contact forces, we get the i-th acceleration for each particle, \( a_{ni} \). Integration of time to acceleration obtains the velocity \( v_{ni} \). Further integration
of time to velocity will produce a position every time for each particle, $r_n$ [12]. This position then visualized the geometry of each particle. For the initial position of each particle, we random the geometry for $N = 1000$ particles, as shown in Figure 2a and 2b.

Fig. 2a. The initial condition for the straight wall (0°).

Fig. 2b. The initial condition of the inclined wall (15°).

3 Results

We generate and increment the initial velocity for each particle in two different wall boundary. Figure 3a-3d show the initial condition when generate the velocity of 2 m/s, 10 m/s, 18 m/s, and 22 m/s respectively in the straight wall boundary. The final condition of these initial conditions shown in Figure 4a-4d.

Fig. 3a. The simulation using 2 m/s velocity for 0° wall.

Fig. 3b. The simulation using 10 m/s velocity for 0° wall.

Fig. 3c. The simulation using 18 m/s velocity for 0° wall.

Fig. 3d. The simulation using 22 m/s velocity for 0° wall.

Fig. 4a. The final condition of 2 m/s velocity 0° wall.

Fig. 4b. The final condition of 10 m/s velocity 0° wall.

From Figure 3a-3d, we observed that granular particle gushes in a diverging direction and observes some particles coming out of the boundary, as the final condition for straight wall boundary as shown in Figure 4a-4d.
The inclined wall boundary inspired by the previous study which simulates the granular flow in the inclined plane [13]. In this work, the inclined wall gives different geometry when generating the initial velocity of each particle. Figure 5a-5e show the initial condition when generating the velocity of 2 m/s, 10 m/s, 18 m/s, 22 m/s, and 26 m/s respectively in the inclined wall boundary.

From Figure 5a-5e, we observe that granular particle gushes in converges direction for the inclined wall. For the 18 m/s, 22 m/s, and 26 m/s initial velocity, no coming out particle as the final condition shown in Figure 6a-6e.
The simulation result can determine the future simulation model. The associated models include the simulation of particles taking account of other forces [14] and continuum flow simulations using granular characters [15]. The important result from this work is how the inclined plane can converge the movement of the granular particle. Further observation is required regarding this slope optimization in some physical cases.

4 Summary

As a summary, we succeed to simulate granular particle in wall boundary using the rigid body properties. We will use a set of the inclined wall for future work because it can hold the particles that pass through the wall. This system can be used in flow retention or energy damping applications.

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