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GRANULAR SEGREGATION OF NON-SPHERICAL PARTICLE IN A QUASI 2-DIMENSIONAL SYSTEM

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Abstract:

Segregation is a very important from industrial point of view. Granular materials segregate due to difference in size, shape & density. We have studied segregation phenomena/pattern in a quasi two-dimensional rectangular bin separated by a gap of 30 mm. Experiments were carried out using model granular material and rice (different aspect ratio). Parameters varied in the experiments are feed composition of granular materials. The heap is formed by repeatedly pouring a fixed mass of the mixture intermittently. Images are captured using digital camera. For analysis ImageJ software was used. Different segregation pattern were obtained due to the change in aspect ratio of rice. Each experimentwas repeated three times to get average data.

Key Words: Segregation, Heap, Granular materials.

Introduction:

Granular materials are very intricate in dynamics; they are large group of particles. Moreover, if they are not cohesive, then the forces between them are mostly repulsive, which leads us to determine the shape of the material by gravity and external boundaries. If the materials are dry, then the fluids between them, such as air can be neglected in determination of the properties of the system. When galvanized, they exhibit wide range of pattern. These pattern forming behaviours are characterized by their dependence of chute inclination and geometry. Granular materials play vital role in our industries such as pharmaceutical, chemical and food industries, civil engineering and mining agricultural, basically anywhere, wherever granular materials are involved. Their mechanisms are also very important for geological processes where landslides, erosion and plate tectonic determine the morphology of the earth. Practically, even the snow on the mountains is very close to the angle of repose that even a small disturbance will create an avalanche. Segregation phenomenon has been investigated in the past using different geometries like rotating cylinder, inclined chute, hoppers. A very few studies have been reported in the literature on segregation during heap formation. In most of the cases feeding is continuous however, intermittent feeding of granular materials is also important in some practical flows. Stratification was observed by Makes.et.al. [7] when a mixture of grains poured between two vertical plates to form heap differing not only in size but also in shape. The key parameter for stratification is a difference in the repose angles of the two pure species. Goal and Tomassone [8] observed size segregation when binary mixtures of granular materials, differing in size and shape, are poured into quasi-two-dimensional silos. They reported that depending on the size ratio $d2$ /$d1$ of the species, the mixture segregates completely or partially. The objectives of the current study are

- The segregation pattern in quasi 2-dimensional systemby using different size of rice.
- Investigate the effect of intermittent feeding on the plot of the angle and shape of heap.

Experimental Method:

Experiments were performed in Quasi 2-dimensional system. Experimental setup consists of two vertical, parallel acrylic plates (90cm X 60cm). As acrylic sheets are transparent by property hence they are used to facilitate imaging. The gap between two vertical plates is 20 mm. A wooden divider forms an inclined chute to feed the mixture. Hopper was used in order to feed the materials from the top. Experimental setup is shown in figure along with the schematic diagram. Different rice of length such as 2mm, 4mm, 3mm and 5mm were used as feed mixture. Rice were colored using different food colors in order to differentiate according to their size, so that it will find convenience while analysis using photographic method. Three different combinations of rice were created. For first combination, rice of 2-4mm were taken. For second combination, rice of 3-5mm were taken. For third combination, rice of 4mm and 5mm rice were used. While creating such combinations, mixtures were created using 50% of smaller size and 50% relatively larger size. At first mixture was created having weight of 200gms, this mixture was then feed from the top of the model. Photos were then taken using digital camera, captured images have a resolution of 4272x2848 pixels; one pixel is equal to 0.0933mm. These experiments were then repeated three times to get the averaged data. We make sure that photographs were then taken after each feeding.

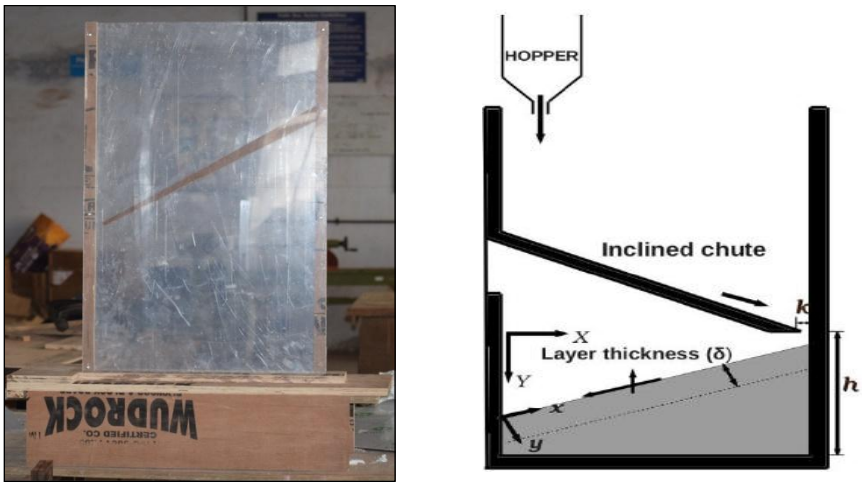
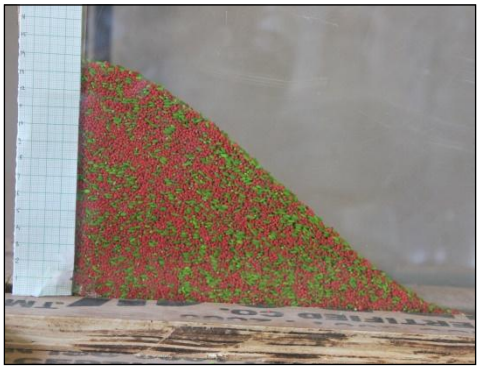


Figure 1: Experimental setup and schematical diagram of the Quasi 2 dimensional model

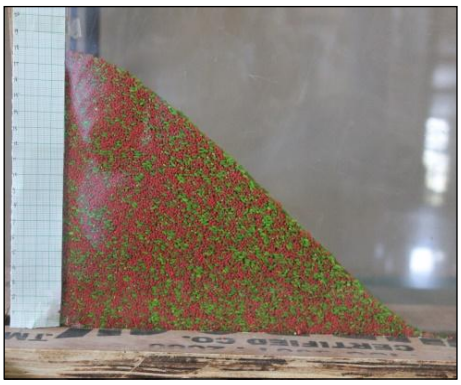
3. Results and Discussion:

1) Combination 1- Red rice – 2mm, Green rice – 4mm

Feeding 1

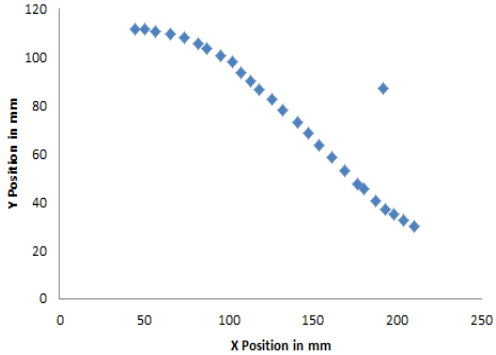


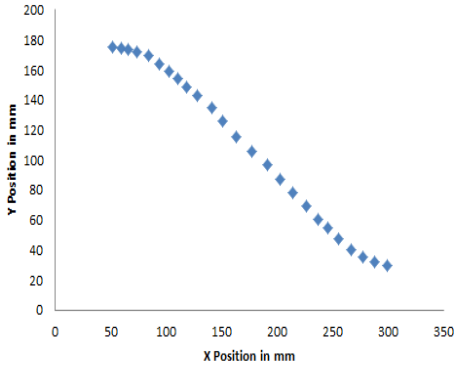
Feeding 2

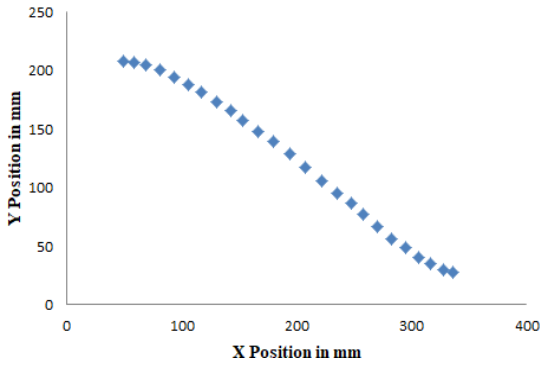


Feeding 3

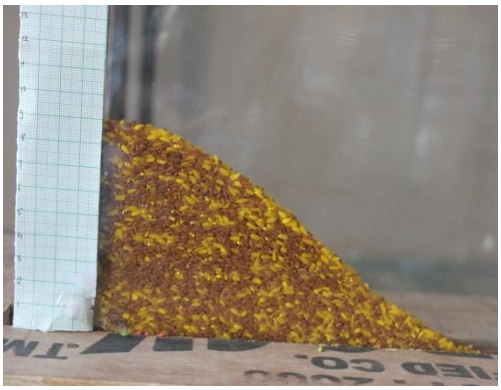
Figure 2: X Position vs Y position in mm, heap profile after each feeding

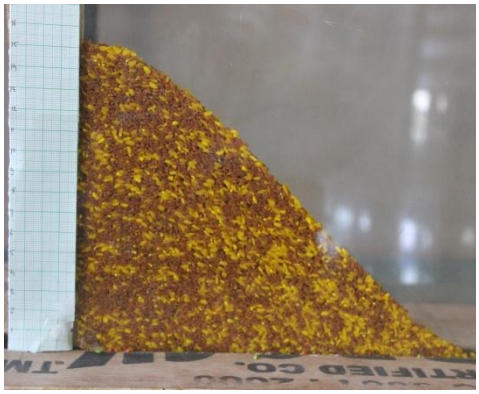


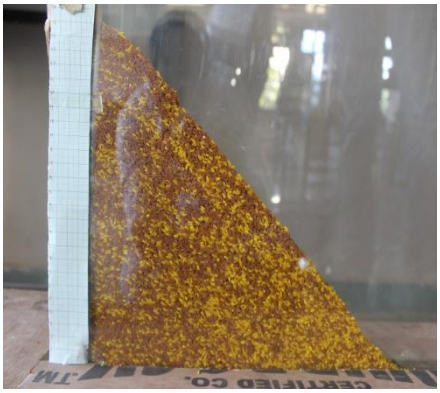


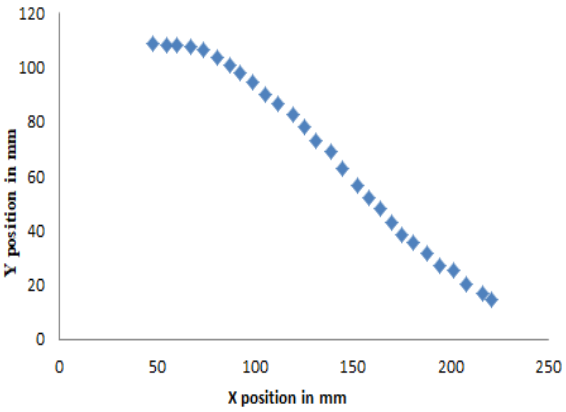


2) Combination 2 Yellow rice – 3mm, Brown rice – 5mm

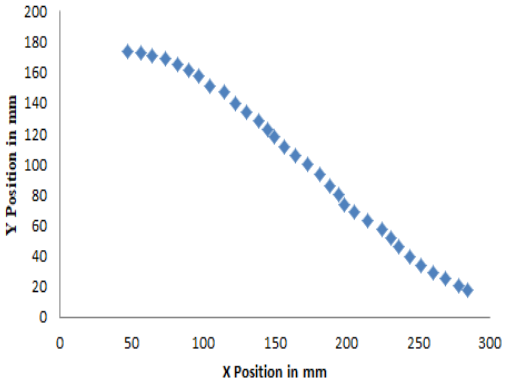




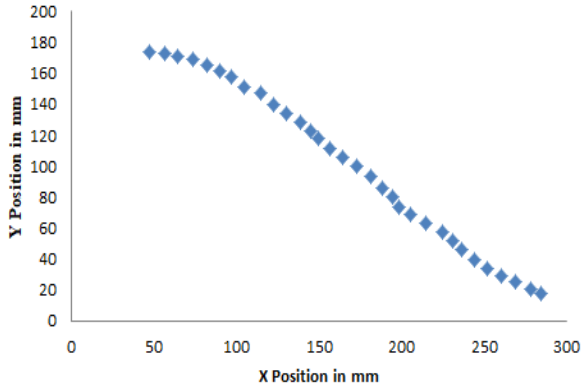




Feeding 1

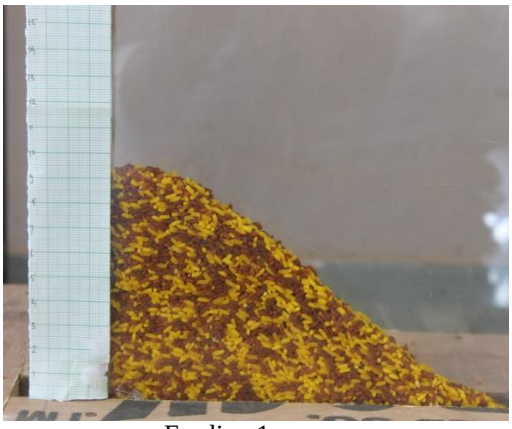


Feeding 2

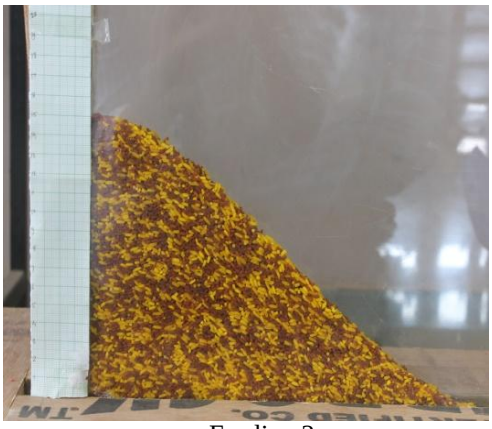


Feeding 3

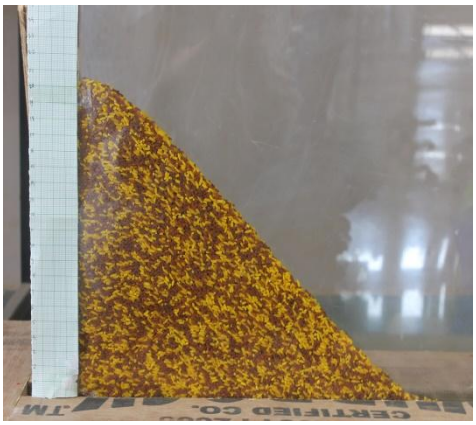
4) Combination 3 Yellow rice – 4mm, Brown rice – 5mm



Feeding 1

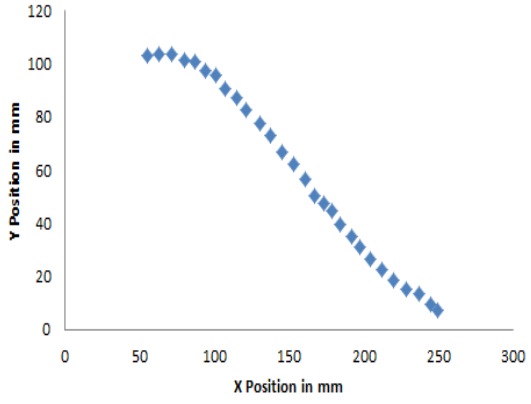


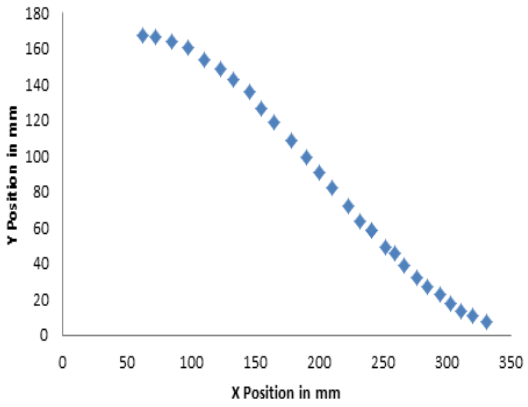
Feeding 2

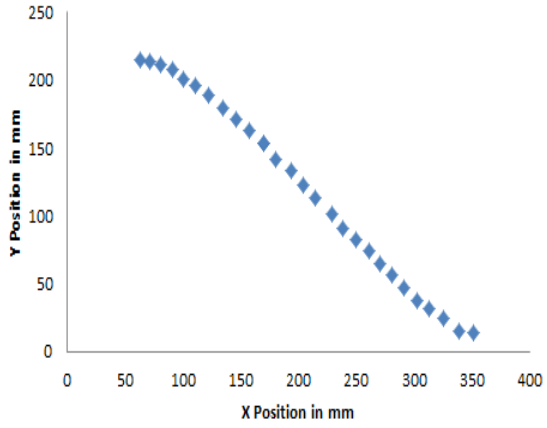


Feeding 3

Figure 4: X Position vs. Y position in mm, heap profile after each feeding







5) Table 1
Angle of repose after each feeding

Angle of Repose (θ)

Combinations	Feeding 1	Feeding 2	Feeding 3
Combination 1	32.53	35.62	37.75
Combination 2	36.02	39.19	38.89
Combination 3	36.90	38.79	38.17

As discussed in the experimental section intermittent feeding was adopted. In order to plot the graphs from photograph, image j software was used. In image j software pixels were first converted from photographs into mm, which were then used to plot the graph of the different profiles obtained. Also angle of repose was measured using image J software. The pattern of segregation obtained by image analysis for different combination are shown in figure 2,3,4; combination 1 where red rice is small and green rice is large, combination-2 where yellow rice was small while brown rice was large and combination-3 where yellow rice (of different size, unlike combination 2) is small and brown rice was large. All three figures clearly indicate smaller particles being deposited in the upper part of the heap. However, from these images it can also be implied that segregation is not complete, as large particles can be seen in upper region of heap. Increase in concentration of large particles simultaneously increases segregation. This phenomenon of segregationoccurred due to the fact that, when mixture was poured, the smaller particles were segregating to the bottom portion of the heap. But, due to the discontinuous feeding the concentration of smaller particles was seen moderate on the upper portion of the heap and thus segregation was avoided at some extent and uniformity was achieved.Also, from the plots of all images parallel to each image, it was observed and was obvious that with each feeding the heap which was initially smaller was increased. From the table 1for all different combinations and with respect to each feeding it can be observed that with increasing heap, angle of repose was also increasing. It was observed that the large rice were more concentrated on the bottom tail portion of the heap, this occurred due to the phenomenon of mass, as the larger rice possess greater mass relative to the smaller one they travelled more distance while heap was being formed.

Conclusion:

- We studied the Segregation of granular materials in simplified model using different sizes of rice as a granular material. Segregation was avoided till some extent, intermittent feeding played vital role in avoiding it.
- It was observed that shape of heap and angle of repose changed after intermittently feeding of material every time.
- Larger particles travelled more distance due to which it was observed that larger particles were more concentrated at the bottom tail of the heap.

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