PEPPER POT

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ABSTRACT

In this essay, the motion of the particles inside a container have been investigated. When something is rubbed along the bottom of the container, the amount of the particles pouring out will increase. In this paper the main reason of the phenomenon has been explained and also some affective parameters such as the particle poured inside the contain, the area of the holes of the container have been investigated.

Key Words :*particles, container, motion, affective parameters*

1 Introduction

This experiment is about the motion of particles inside a pepper pot. If we shake a paper pot, number of the particles poured out will be low but if we rob something along the bottom of it this amount will increase. In this paper, a method had been presented to investigate in which cases the amount of pouring out the particles will be higher.

The main reason that this amount increases is because of vibration which is applied to it from rubbing. When we rub the pepper pot the agglomeration cannot happen between the particles so the amount of pouring out increases.

Some parameters can affect this vibration. These parameters contain the scrubs speed, the hoppers material and the geometry of the particles.

2 Experiments and Methods

A motor on a stand has been used to rob the pepper pot. The angular velocity of the motor was constant. the material of the hopper was glass with a cylindrical shape (Fig. 1).

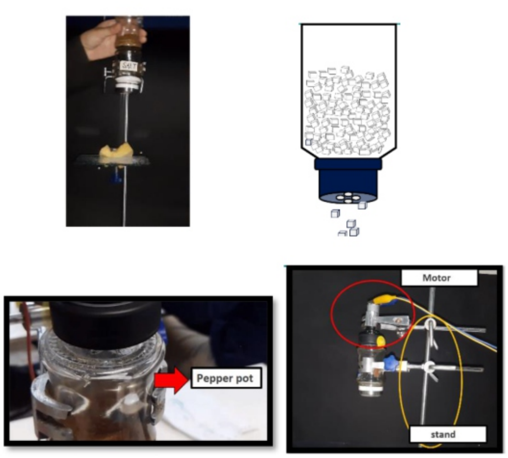


Fig. 1: Pepper Pot experimental setup

3 Theory

3-1 Agglomeration

In normal situation the middle atoms are dragged from all around but some energy is left on the surface atom which makes the Agglomeration, Van der Waals forces between the particles, to happen (Fig. 2).

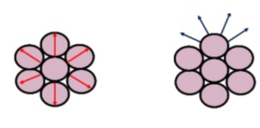


Fig2: Energy on the surface of the particle

That means the small particles will merge and make a bigger particle which cannot pass through the holes of the pepper pot easily (Fig. 3).

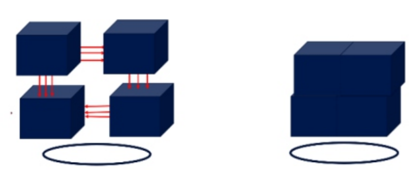


Fig 3 : Agglomeration making bigger particles

In normal situation, when we shake the pepper pot the agglomeration will cause the amount of pouring out to decrease. The motion of the particles had been investigated in vibrating system (Fig. 4).

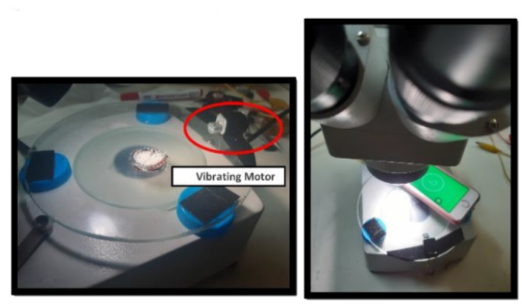
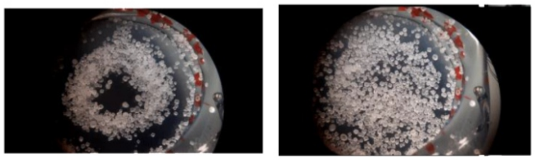


Fig 4 : Investigating the motion of the particles in vibrating systems

The particles want to be in the least energy possible. The least energy possible is in the most symmetrical state.

When the vibration is applied to them from the vibrating system, the particles are able to move and be in the most symmetrical state. So they will decrease the free space left on the surface and spread all around (Fig.5a and b). There will be some distance between the particles and the particles will move permanently. So in vibrating systems, the agglomeration cannot happen.



(a) (b)

Fig5: a) Particles before the vibration ; b) Particles after the vibration

It is approximately the same in the pepper pot. When the pepper pot is robbed, waves will be formed. This waves decrease the agglomeration so the particle will not merge and they will cover the hole. Therefore, the amount of pouring out increases (Fig. 6).

Fig. 6: Waves formation

3-2 Mass

Number of the particles over area had been defined as a variable (Eq. 1):

$$n = \frac{Number\ of\ particles}{Area} \qquad nA = N \tag{1}$$

where A is the area of the holes. To solve this problem, the acceleration of layer pouring out must be considered constant. That means, the layers of the particles must affect each other so the mass of the particles poured inside the pepper pot (which affect the number of this layers) cannot affect this phenomenon. Therefore, mass poured out in each second will be constant. by adding the coefficient α to the equation the mass poured out in each second is found (Eq. 2).

$$\dot{N} = \propto nA \tag{2}$$

The particles are covering all around the hole so they cannot affect each other and the only external force which is affecting the particle passing through the hole is gravity. Then (Eq. 3 and 4):

$$\dot{M} = \dot{N}m = \propto nAm = \beta \tag{3}$$

$$M = M_0 - \beta t \tag{4}$$

According to these equations the effective parameters are the particles we pour inside the pepper pot and the number of the holes which can affect the area.

4 Experimental Procedures

4-1 The Constant Acceleration

The constant acceleration of this layer have been investigated in experimental data to approve the consideration. As it had been mentioned in theory , by have a constant acceleration for each layer $\dot{M}$ will be constant. So the slope of the mass poured out per time must be constant and the trend line passing through experimental results, must pass through zero. Also the mass poured inside the pepper pot won't affect this phenomenon (if the acceleration of these layers are constant) . Then different mass poured inside the pepper pot have been investigated as one of the parameters.

According to Figure (7), changing the mass inside the pepper pot which affect the number of the layers, cannot affect this phenomenon and this approves that the acceleration of the layers is constant and the same till the end of the pouring out.

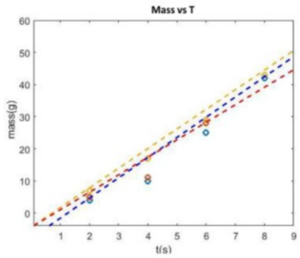


Fig 7: Mass poured out in each second versus time (different mass poured inside the pepper pot)

3-2 Affective Parameters

According to the equation (3) changing the number of the holes can affect the area and as much as number of the holes increases the mass poured out in each second will increase (Fig. 8).

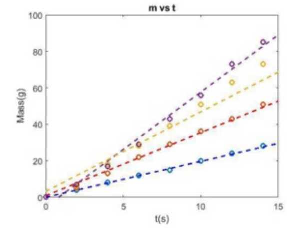
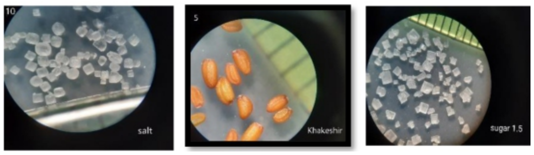


Fig 8: Mass poured out in each second versus time (area)

Three different particles have been investigated too. (salt, sugar, flixweed seed).



Particle	mass	dhole	Geometry	S
flixweed seed	1.88gr	1.53mm		$0.038163 mm^2$
salt	6.6gr	1.53mm		$625 mm^2$
sugar	0.37gr	1.53mm		$0.571536 mm^2$

Fig 9: Experimental Results

Mass column gives us the mass poured out in each second. For example, in two seconds 1.88g seed and 6.6g salt came out from the pepper pot. This column gives us the ability to compare this particle experimentally. To compare the particles theoretically (Eqs. 5 and 6):

$$\varepsilon = \frac{S(empty\ space)}{S(total)} \quad (5)$$

$$A = \frac{N.S(particle)}{S(total)} = 1 - \varepsilon \quad (6)$$

When the amount of empty spaces decreases the number of the particles filling the hole will increase. But when we have large particles Ɛ will increase . So the number of the particles and mass poured out in the same time will decrease. For different particles:

$$A_{salt} = \frac{N_{salt}.S_{salt}}{S_{total}} = N_{salt}.R_{salt}$$

$$S_{total} = S_{hole} = \pi r_1^2$$

$A_{salt} = 24 \times 0.041 = 0.984$
$\mathcal{E}_{salt} = 1 - 0.984 = 0.016$

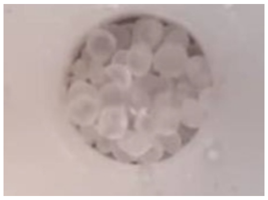


Fig 10: Salt particles inside the hole

and the same for other particles:

Fig 11: Flixweed seed particles inside the hole with Ɛ=0.187

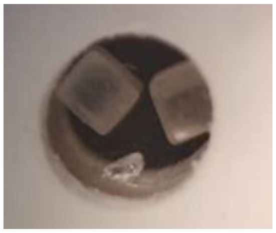


Fig 12: sugar particles inside the hole with Ɛ=0.124

The shape of the particles will cause some mismatches in experimental and theoretical results. sugar is cubic and it has sharp apexes but seed doesn't have any apexes so it can pass through the hole easier. The name of this effect (effect of the shape of the particles) is steric effect. The steric effect must be considered in our results.

Some other particles had been investigated as well. Because pepper has sharp apexes it cannot pass through the hole easily and the amount of pouring out decreases.

But when it is filled with flour the amount of pouring out increases but not as much as it was expected because the $\mathcal{E}$ of the flour is low.

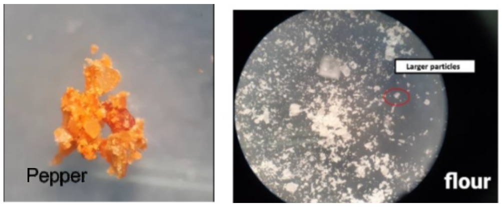


Fig. 13: Pepper and Flour particles

In equation (4) β is constant so the trend line passing through experimental results must pass through zero and theory versus experiment results are approximately matched.

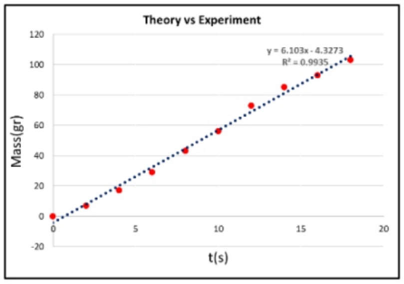


Fig. 14: Mass poured out in each second versus time (theory vs experiments)

4 Conclusion

Agglomeration was the main reason which made the amount of pouring out to be low in normal situation. All the experiments show agglomeration cannot happen in vibrating systems. The acceleration of the layers of different particles have been considered constant. The particles poured inside the pepper pot and the number of the holes are important parameters.

The shape of the particles as the steric effect was investigated too.

In theory the same as in experimental results it is found that the particles will cover all around the hole but in the end of the pouring out (in experiments) particles are not enough to cover all around the hole so the amount of pouring out decreases as an experimental error.

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