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# Studying the Factors Effect on the Flowability of ($ZnO – CuO/\gamma\,Al_2O_3$) Catalyst with Blending of Different Lubricants through Hopper

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## Abstract

One of the most important problems in tablet process is to control the flow of the catalyst through the hopper; Controlling the flow can be done either by changing the size of particles or added the different lubricant (stearic acid, starch, graphite) or blending of different lubricants. The study showed that we can control (increase or decrease) on the flow of the catalyst through the hopper by blending different lubricants for the constant percentage. The flow increasing when particles size (0.6 mm) and then decrease with or without lubricants, no effect on flow when particles size lower than (0.2 mm) with use that lubricants, and good flow on (0.4 mm) when use stearic acid and starch.

***Keywords:*** Catalyst, hopper, tablet machine, and powder blending.

## 1. Introduction

The catalyst used in this research was ($ZnO – CuO /\gamma\,Al_2O_3$) which was in exyrogel phase, green color, non cohesive powder. This catalyst is calcined after tableting process to become finished catalyst Zinc – Copper over Gama Alumina ($Zn – Cu /\gamma\,Al_2O_3$) in gray color.

Adding lubricants to catalyst is important to improve the flowing of the catalyst through the hopper and facilitating the tableting process in the tablet machine [1]. The lubricants affect the flow; compaction; and ejection behavior. Some of lubricants will decrease the flow and decrease ejection; others such as graphite will improve all the flow and ejection [2].

In the mixing of solid particles, the following three mechanisms may be involved [3]:

**(a)** Convective mixing, in which groups of particles are moved from one position to another,

**(b)** Diffusion mixing, where the particles are distributed over a freshly developed interface, and

**(c)** Shear mixing, where slipping planes are formed.

Lubricant levels are a delicate balance between achieving good flow and achieving good compressibility. Often, there is no magic amount of lubricant or post addition blend time that will account for variations in the excipients or the lubricant itself. By monitoring lubrication real time, physical characteristics of powder flow and tablet quality can be determined predicatively. The effect of lubricant addition to a uniform material can be clearly identified with thermal effusively. Thermal effusively relates to a material’s ability to transfer heat. When magnesium stearate coats the particles, it causes the density of the granulation blend to increase, and the heat to transfer more readily. This is measured through the increase in effusively after the lubricant is added. By monitoring the blend lubrication states in advance, operators can take preventative action taken during blending or use the information upstream and initiate appropriate actions to produce quality tablets. The lubricant blending processes is an important component in the development and scale-up of process applications [4].

Lubricants typically used in tableting operation are graphite, starch, talc, stearic acid and others [5]. Figure (1) [6] illustrates the blending of the particles with different lubricants which are very important in flow behavior of the catalyst, (1.A) shows the small particles with lubricants which have same particles size, (1.B) shows the medium particle sizes with lubricants without change in size, (1.C) shows the large particles with lubricant.

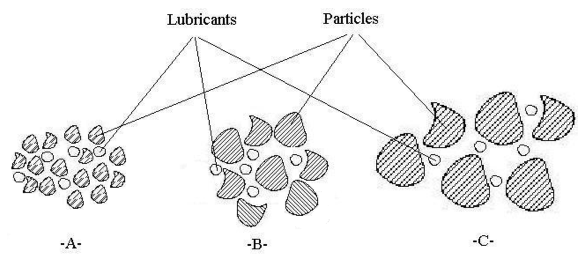


**Fig.1. Particles – Lubricants Mixture [6]**

The effect of lubricants on catalyst as tabulated in table below:

**Table 1,**
**Effect of Lubricants on Catalyst Application [7]**

| Lubricants | Effectiveness application on catalyst |
|---|---|
| Stearic acid | Good |
| Starch | Not effect |
| Graphite | Excellent |

Magnesium stearate has disadvantage effect on flowability of powder, but when using stearic acid will give improvement in the flowability Fig. (2) [8].

The aim of the study is to show the effect of flow ($ZnO$ – $CuO$ / $\gamma$ $Al_2O_3$) catalyst by using different types of lubricants (stearic acid, starch and graphite) with blending of them, to show their effects on the mass flow of the catalyst through the hopper. Lubricant content of (11 %) by weight were used.

The time of mixing is greater than two minutes to ensure the lubricants blending with catalyst [9].

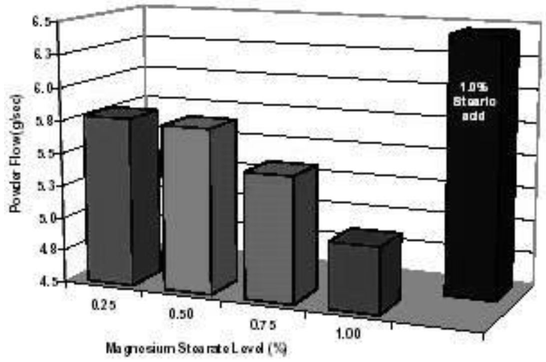


**Fig.2. Effect Stearic Acid on Powder Flowability [8]**

## 2. Experimental Work
## 2.1. Lubricants Blending

In present investigation a batch blending process was used. A typical batch blending system is shown in figure (3). The basic components are a blender, one or more portable or stationary containers, and a chute to a process, e.g., a tabletting press [10]. The blending time of the lubricant was about 2 – 5 minutes [11].

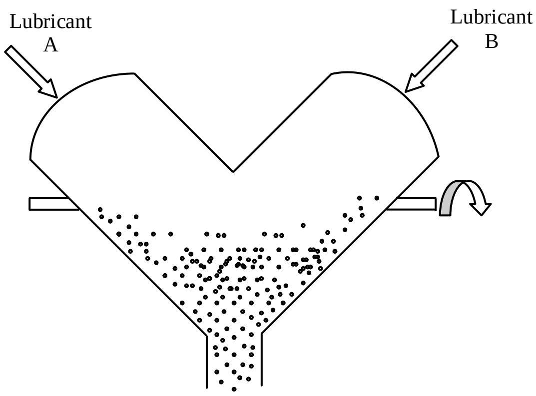


**Fig.3. Lubricants Blender**

## 2.2. Catalyst Flow

In this research a special hopper was used to measure the flow of catalyst (which has the same dimensions of the hopper in the "AL – Rayah State Company" which is used in the tablet machine) as shown in Figure (4).

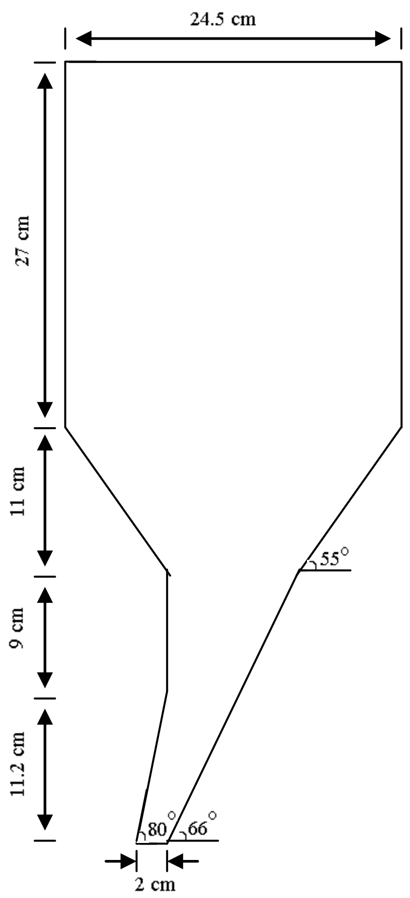


**Fig.4. Special Hopper**

The mass flow rate of powder (g/s) was measured using the flow procedure:

**1-** Weighing the catalyst (W).
**2-** Allowing the catalyst to pour through the hopper, and calculate the time (t) needed for the catalyst to drain.

$$\text{Mass flow rate} = \frac{W}{t} \quad \text{... (1)}$$

Lubricants were used as additives to the catalyst. Three different types of lubricants (stearic acid, starch, and graphite) were prepared and with blending of these types at (11 %) weight percentage, (stearic acid + starch, stearic acid + graphite, starch + graphite, and stearic acid + starch + graphite), the procedure was as follows:

**1-** Weigh a sample of cut used (W).
**2-** Calculate weigh of lubricant content percentage used ($W_L$) which mixed it with the catalyst, for example, when used (11 %) of lubricant:

$$W_L = \left[\frac{W}{(1-0.11)}\right] - W \quad \text{... (2)}$$

**3-** Mixed the catalyst with lubricant and weigh them ($W_M$).
**4-** Allowing the mixture to pour through the hopper, and calculate the time (t) for the mixture to drain.

$$\text{Mass flow rate} = \frac{W_M}{t} \quad \text{... (3)}$$

Three measurements were made for the catalyst and the mean value is taken as the true mass flow rate.

## 3. Results and Discussion:

From figures (4 – 7), it is clear that by blending of lubricants, can control the mass flow through the hopper, graphite always lowers the flow, starch promotes the flow, and stearic acid has a moderate effect (positive) on the flow. It is clear that blending starch and stearic acid will give the highest mass flow rate (comparing with the other lubricants' blending), that is due to non – cohesiveness nature of starch.

Graphite lowers the mass flow rate because it is molecules form layers over lap over another layers [2].

Lubricants contribute significantly to agglomerate strength, lubricants through the reduction of particle-particle friction to allow lower void fraction and closer particle contact. Lubricants are most relevant to pressure methods of size enlargement where they may also act as mold release agents [7].

Figures (5 – 8) show that, the mass flow rate at (0.6 mm) reach to the maximum value because the size of catalyst particles increased the effect of lubricants in the flow becomes clear than the cut of small size., and then fall down because the flow depend mostly on the particles size of catalyst, the diameter of hole of the hopper which is (2 cm) is fixed and the size of particles became larger (0.72 mm), therefore, the particles were crowded and do not able to flow through hopper. Therefore the resistance of flow will be high, but generally the catalysts have good flow rate comparing with the results of figure (9). The adhesion increases with increase contact area [12].

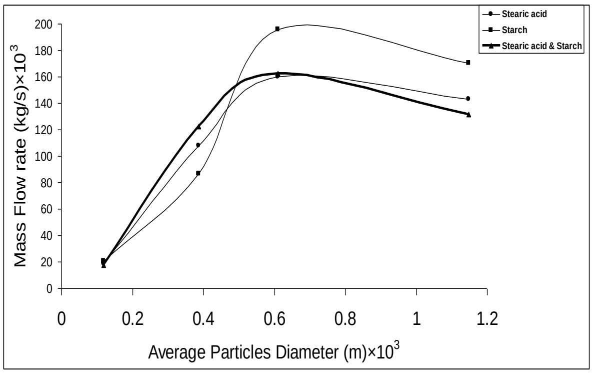


**Fig.5. Effect Particles Sizes on Flow With Blends (Stearic Acid & Starch)**

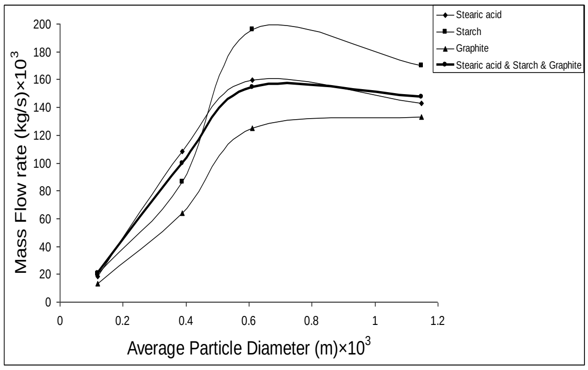


**Fig.8. Effect Particles Sizes on Flow With Blends (Stearic Acid & Starch & Graphite)**

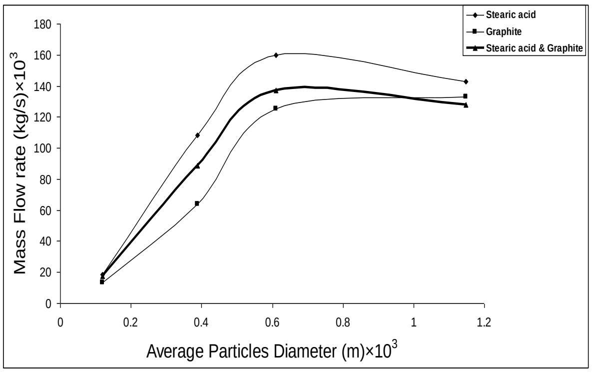


**Fig.6. Effect Particles Sizes on Flow with Blends (Stearic Acid & Graphite)**

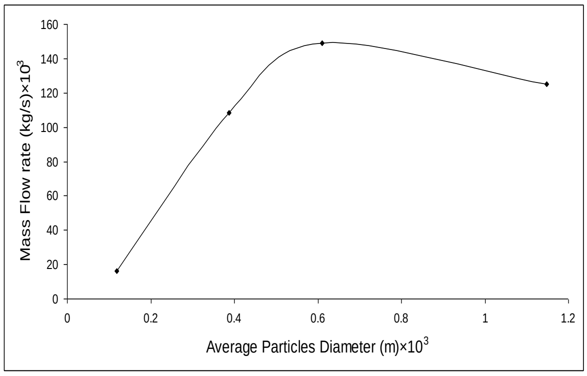


**Fig. 9. Effect the Particles Sizes on the Flow (Without Lubricants)**

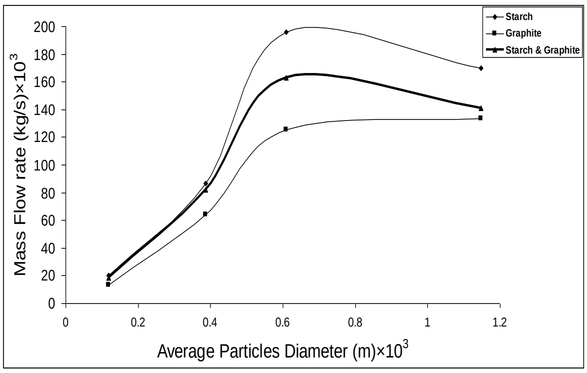


**Fig.7. Effect Particles Sizes on Flow with Blends (Starch & Graphite)**

Figures (10 – 13) show that the lubricants blend was improved the flowability of catalyst before distribution comparing to the previous batches containing lubricants [13].

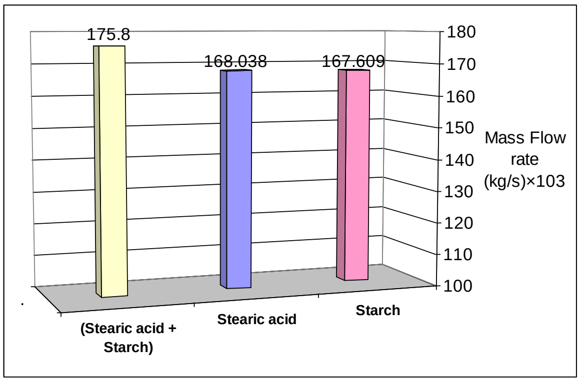


**Fig. 10. Mass Flow Rate of Blends (Stearic Acid & Starch) Lubricants for Catalyst Before Distribution**

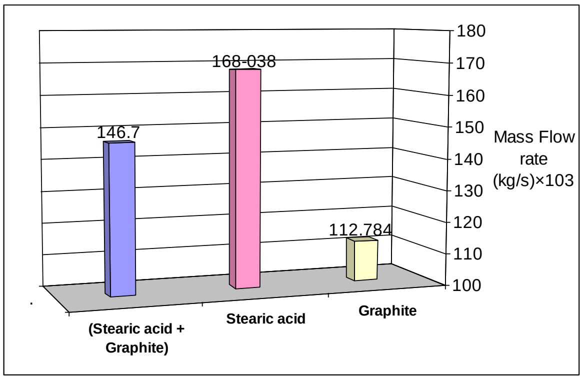


**Fig.11. Mass flow rate of Blends (Stearic Acid & Graphite) Lubricants for Catalyst before Distribution**

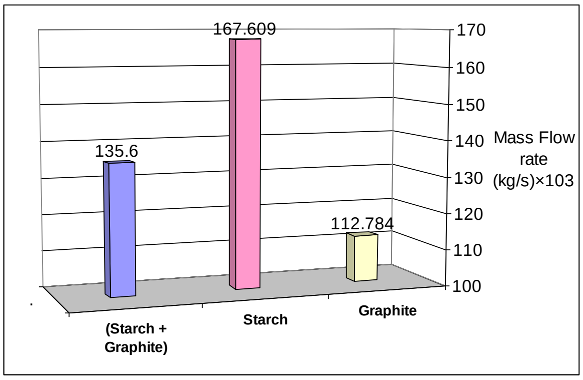


**Fig.12. Mass flow rate of Blends (Starch & Graphite) Lubricants for Catalyst before Distribution**

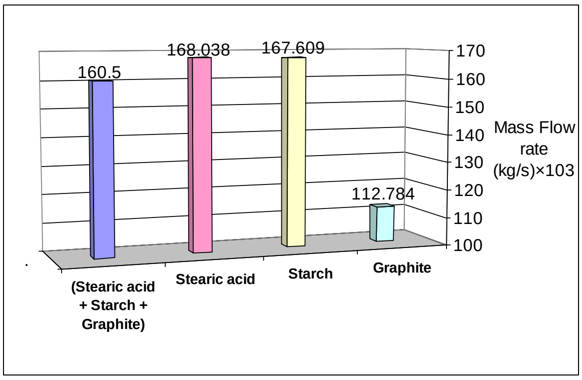


**Fig.13. Mass Flow Rate of Blends (Stearic Acid & Starch & Graphite) Lubricants for Catalyst before Distribution**

## 4. Conclusions

**1-** The flow of catalyst (with or without lubricants) through the hopper depends upon the particles size, the flow increases with particles size until (0.6 mm) and then decrease.

**2-** The flow of catalyst through the hopper can be controlled by blending different types of lubricants, e.g. (stearic acid, starch, and graphite).

**3-** The lubricants (stearic acid, starch, and graphite) show low effect on flow when particles size lower than (0.2 mm).

**4-** Stearic acid and starch have good lubricant properties when particles size more than 0.4 mm.

## Nomenclature

| | | |
|---|---|---|
| t | The time of drain catalyst | (s) |
| W | Weight of catalyst | (kg) |
| $W_L$ | Weight of lubricant percentage | (kg) |
| $W_M$ | Weight of catalyst – lubricant mixture | (kg) |

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# دراسة العوامل المؤثرة على انسيابية العامل المساعد (ZnO – CuO/) $Al_2O_3\gamma$ مع مزج مزيتات مختلفة خلال القمع

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**الخلاصة**

احدى اهم المشاكل في عملية الكبس هي السيطرة على جريان العامل المساعد خلال القمع، السيطرة على الجريان يمكن ان يعمل اما بتغيير حجم جزيئات العامل المساعد او أضافة المزيتات المختلفة (حامض الستريك، النشا و الكرافيت) او مزج مزيتات مختلفة. الدراسة بينت بأننا يمكن ان نسيطر (زيادة او نقصان) على جريان العامل المساعد خلال القمع بمزج المزيتات المختلفة للنسب المئوية الثابتة. الجريان يزداد عندما حجم الجزيئات ( 0,6 مم) وبعد ذلك يتناقص مع او بدون المزيتات، لا تأثير على الجريان عندما ينخفض حجم الجزيئات عن (0,2 مم) مع استعمال تلك المزيتات، وجريان جيد في (0,4 مم ) عند استعمال حامض الستريك والنشا.