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Investigation for Strength of Layering of Pelletized Balls Used As Feed for Gas Solid Reaction

P. Sagar Suresh Rao, V. Suman, V. Vamshi Krishna, Savita Belwal, M. Bhagvanth Rao

Department of Chemical Engineering, CVSR College of Engineering, Anurag Group of Institutions, Hyderabad, India

ABSTRACT

To bring the mandatory changes in feed preparation of conventional methods of gas solid reactions the method of pelletization is introduced. This paper provides the best case of balls which are sustainable to pressure maintained for gas solid reaction so that desired size and production rate of balls can be achieved. Pelletization is agglomeration technique which is beneficial with fine powder to improve feed preparation present in the gas solid reaction. This technique is useful to increase production rate and to reduce the difficulties which occur in production by mechanical means with heavy mechanical operating devices. Currently many of the chemical industries are using briquettes for gas solid reaction which consume extra power, cost and time. Hence this can be substituted by using pelletization and material science technique. Pellets should be improvised alternated feed preparation for gas solid reaction as manufacturing of pellet consumes less time and power. It has better surface area and porosity when compared to the briquettes. Few sets of experiments have been done to overcome factors affecting in pellet making and positive result are observed.

Key words: Pelletization, material science technique, feed for gas solid reaction, layering, agglomeration and kinetics.

I. INTRODUCTION

This technique is beneficial with fine powder [1-2]. Pellet making involves balling[3] of the fine powder of dust[4] with addition of definite amount of moisture and binder by using rotating drum. Drum pelletizer can be used as batch process. In this method particles of solid are first coated with water and due to surface tension effects of water coating collision occur with adjacent particles to form large particle and start to form pellet. Extensive applied research and industrial plant scale testing are directed to understand and improve the duration process and quality of the ball. This technique can be observed with help of following phenomena[5].

A. PELLETIZATION: Pelletization[6] includes the following steps.

1. NUCLEATION:

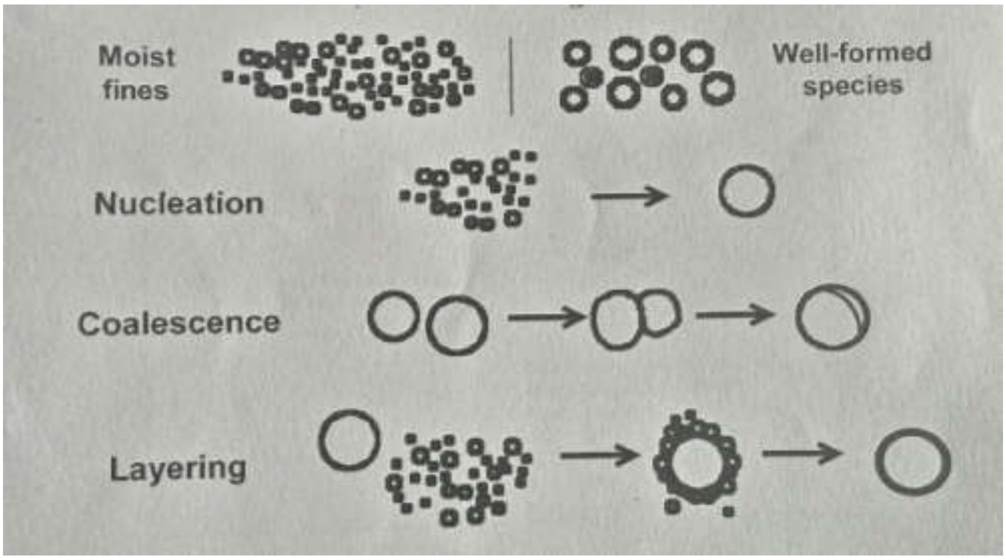
This is initial and one of the most important steps in ball making. In this method, finite numbers of fine particles club together to form well nucleated species.

2. COALESCENCE:

In coalescence[7], finite numbers of well nucleated particles club together to form a large and better molecule.

3. LAYERING:

Layering is one of the important factors for increasing the size. In this part, small well agglomerated fine particles[8] will start layering on the surface of well nucleated as well as coalescence molecule in order to get desired size.



II. FACTORS AFFECTING PELLETIZATION

1. MOISTURE CONTENT:

Moisture content is always one of the most influencing factors on pellets strength and durability. The right amount of moisture functions as an agent during the process of pelletization which influences the pellet strength[9] and durability.

2. PARTICLE SIZE:

Particle size is one of the most important factors affecting overall quality of pellets[10,11]. Finer particle sizes generally correspond with greater pellet strength and durability as larger particles serve as fissure points. A mixture of particle sizes produces optimal pellet quality due to the increased inter-particle bonding and the elimination of inter-particle spaces. The size of particle plays a significant role to the working life of pelletizing equipment. The finer the size of particle the longer the serving life of the pelletizing equipment[12].

3. BINDER:

Binders are used to assist the pellet formation and increase the pellet durability to avoid the decomposition during storage. Binder provides the additional strength and durability after removal of moisture. It also provides extra strength during transportation.

4. TIME OF ROTATION:

It plays the important role for ball formation and desired size. It provides extra sense for layering after better nucleation and agglomeration of particles. Layering is directly dependent on time of rotation if fines are available.

B.GAS SOLID REACTION:

Gas solid reaction[13-15] provides a practical approach of pelletization or ball making. Powder cannot be used directly for gas solid reactions since the passage of gas is not possible because of tight packing of the powder.

Since there is disturbance in distribution or passage of gas so powder is preferred to convert into pellet or ball with the help of binder for suitable distribution or passage of gas through solid.

A (gas) + bB (solid) $\longrightarrow$ **Products**

In recent years a great deal of work has been done on the development of alternatives to the shrinking core model for non-catalytic gas-solid reactions[16]. Much of the earlier work was purely analytical, and only in two very recent studies was there an attempt made to compare the predictions of the models with actual experimental measurements. A common feature of all these models is the postulate that the reaction takes place on a distributed surface, within the porous[17] body, which is represented as an assembly of individual particles or channels.

In the majority of cases the mathematical representation of these systems led to a set of simultaneous differential equations which had to be solved numerically. The computed results shown in the previous publications served primarily an illustrative purpose, indicating certain trends, for given specific situations. It follows that in their present form the “structural models” available at present are not immediately accessible for the interpretation of experimental data or for the prediction of the behavior of a given system. Therefore it would be desirable to consolidate ideas currently available on structural models into a general dimensionless representation. Ideally such treatment should provide both an overview of the interaction of the various parameters and a convenient framework for prediction and interpretation of experimental data, without recourse to numerical computation in each instance. The purpose of the paper is to attempt the development of such a general model, at least for systems undergoing first order irreversible reactions and where structural changes occurring in course of the reaction may be neglected.

¬ **FACTORS AFFECTING GAS SOLID REACTION:**

1. POROSITY OF PELLETS:

Rate of gas solid reaction[18,19] depends upon the porosity of material. If the porosity of pellet is high then rate of reaction is also fast and vice versa.

2. DIFFUSION:

Diffusion [20, 21]within the pellet is either equimolar counter-diffusion or at low concentration of the diffusing species.

3. SURFACE AREA OF PELLET:

Surface area is one of the important factors because high surface area provides[22] high rates of reaction and high quantity of desired product.

¬ **ADVANTAGES OF BALLS OVER BRIQUETTES:**

1. Ball provides more surface area then briquettes.
2. Ball has more compressive and tensile strength than briquettes.
3. High porosity is achievable in case of ball over briquettes.
4. The observed rate of reaction is high in case of balls than briquettes for gas solid reaction.
5. Low operating and maintenance cost for ball making over briquettes making.
6. Low requirement of energy and man power for ball making over briquettes.

III. MATERIALS AND METHODS

Zirconium oxide, starch, coke, moisture are the raw materials which are used for feed preparation of gas solid reaction. In this moisture and binder helps to achieve agglomeration and material science techniques.

METHOD: DRUM PELLETIZER

1. In drum pelletization the known amount of feed along with definite quantity of moisture and binder is fed to the drum and made to rotate for specified time and allowed for ball formation.
2. This is one of the useful methods of pelletization and it is easy to operate.
3. The quality depends upon the amount of binder and moisture used.
4. The quality of ball is assured on basis of the compressibility test and drop test.
5. This is one of the useful techniques of agglomeration.

IV. RESULT AND DISCUSSION:

SET OF EXPERIMENTS

1. Total feed with total moisture 2. Total feed with stepwise moisture
3. Stepwise feed with stepwise moisture 4. Total moisture with stepwise feed.

1. TOTAL FEED WITH TOTAL MOISTURE

i. WITHOUT MOISTURE :

Feed quantity : 5 kg
Moisture Added : No moisture added
Time forrotations : 20 minutes
Procedure : Take standard feed of 5 kg of perfectly mixed in Rotary drum without adding any moisture and rotate it for 20 Minutes.
Observation : No desired (6 - 8 mm) size ball formation is found. In it fine powder remain same.
Production rate : 0 %
Result : Low amount of agglomerated particles without ball production can be seen.

ii.1% Moisture

Feed quantity : 5 kg
Moisture Added : 1 %(50 ml for 5 kg feed)
Time for rotations : 20 minutes
Procedure : Take standard feed of 5 kg of perfectly mixed in rotary drum and
Sprinkle1 %moisture (50 ml) and rotate it for20 minutes.
Observation : Most of the fine particles are formed in to fine balls (1mm size).
Production rate : 2 %
Result : Agglomeration of particles takes place at better rate but ball production is very Low due to high agglomeration and granulation.

iii.3% Moisture Added:

Feed quantity : 5 kg
Moisture Added : 3 %(150 ml for. 5 kg feed).
Time for rotations : 20 minutes
Procedure : Take standard feed of 5 kg of perfectly mixed in rotary drum and
Sprinkle 3 %moisture (150 ml) and rotate it for20 minutes.
Observation : small quantity of desired balls are appeared and rest of feed is in
Granules form.
Production rate : 5%
Result : high rates of granulation and ball formation is observed but ball size is not desired.

iv. 5% Moisture Added:

Feed quantity : 5 kg

Moisture Added : 5 % (250 ml for 5 kg feed)
Time for rotations : 20 minutes
Procedure : Take standard feed of 5 kg of perfectly mixed in rotary drum and
Sprinkle 5 %moisture (250 ml) and rotate it for20 minutes.
Observation : Large quantity of agglomerated particles are present desired particles size balls are formed in small quantity from the range 1 mm - 10 mm size.
Production rate : 10-15 %
Result : High rates of agglomeration and ball formation is seen and ball formation of desired size can be seen.

v. 7%Moisture Added:
Feed quantity : 5 kg
Moisture Added : 7 %(350 ml for 5 kg feed)
Time for rotation : 20 minutes
Procedure : Take standard feed of 5 kg of perfectly mixed in rotary drum and
sprinkle 7 %moisture (350 ml) and rotate it for20 minutes.
Observation : Excess moisture is observed in each pellet, they are liable to
deformation due to its plasticity. Pellet wall collision and pellet- pellet collision is observed. No fine particles are present in it.
Production rate : 12%
Result : Here rate of ball formation and agglomeration is high along with excess moisture. Lumps formation is further taking place in this case.

2. TOTAL FEED WITH STEPWISE MOISTURE
i. 1% moisture followed by 2% moisture
2% moisture followed by 1% moisture
Feed quantity : 5 kg
Moisture Added : overall 3 %(150 ml) moisture added
Time for rotations : 20 minutes
Procedure : Take standard feed of 5 kg total and sprinkle 1 % (or 2 %) in rotate
drum and rotate for 10 minutes and after sprinkle another 2 % (or 1 %) and rotate for another 10 minutes.
Observation : most of the fine particles are formed in to fine balls (1mm size).
Production rate : 8%
Result : Low quantity of balls and high quantity of agglomerated particles is seen and presence of heavy amount of agglomerated particles lowers the possibility of ball formation.

3. Stepwise Feed With Stepwisemoisture
Feed quantity : 5 kg
Moisture Added : Overall 250 ml (For every 1 kg feed 50 ml moisture is added).
Time for rotations : 20 minutes
Procedure : For every 1 kg Feed 50 ml (5%) is added and made to rotate for 5 minutes and then repeat it for up to 5 kg.
Observation : Small quantity of balls are formed in first rotation, then after adding fine
Particles and moisture nucleation and layering is observed that it continued for continuous process.
Production rate : 33 %.
Result : This is one of the effective way of ball formation which shows better results than other cases and large quantity of ball formation takes place due to step wise addition of feed and moisture which further helps for layering over well nucleated particle. Desired size of ball can be achieved.

4. Total moisture with Step wise feed.
Feed quantity : 5 kg.
Moisture Added : overall 4% moisture for total feed
Time for rotations : 20 minutes
Procedure : Take standard feed of 5 kg and take half of the feed (2.5kg) in rotary
drum and sprinkle 8 % moisture (200ml) and rotate it for 10 minutes. After that add another half feed (2.5 kg)in rotary drum and rotate it for10 minutes.
Observation : In first part pellet-pellet collision and pellet-wall collision is observed.
After adding fine particles without any moisture to it, collision pellets are deformed to different size granules.
Production rate : 45 %.
Result : This is one of the best cases that have been observed during the experiments. Here step wise addition of feed and moisture helps for growth of t ball through one time layering mechanism over well nucleated particle. Any desired size of ball can be achieved in this case. This case provides the best production rate in all experiments.

V. OVERALL RESULT

When compared to total feed with total moisture, excellent result is achieved in total feed with step wise moisture and total moisture with step wise moisture

VI. CONCLUSION

As moisture is increasing pellet formation is also increasing until the excess moisture is reached. Optimum moisture is best for desired pellets. The rate of ball formation depends upon the way of addition of feed and moisture. Moisture and binder quantity plays an important role in providing enough strength to balls after drying and coking which can utilized as alternative feed for gas solid reaction. Various cases of strength of layering of ball can be utilized for the gas solid reaction. Desired size of ball can be achieved through exponential increase in layers of dust particles over a well nucleated ball. Above mentioned experiments can be used for betterment of feed for gas solid reaction.

VII. TECHNO-ECONOMICS

The improved pellet size will be beneficial in following ways:

1. Production of pellets has been seen rapidly through this technique due to minimizing of oversize and undersize pellets
2. Product quality has been seen improved since its better size range serves good bed permeability while induration.

Energy consumption will be minimized since the energy required for recycling the oversized pellets while crushing is prevented to some extent. This can be easily revealed from fact that recirculation has been decreased. Also the continuous availability of fresh material to the indurating furnace increased.
Hence looking at the affecting parameters for ball and briquettes which is favoring to the balls as alternative feed for gas solid reaction may be recommended for future prospectus.

VIII. SUMMARY

S.No.	Conditions	Time	Production rate.
1.	Total feed with total moisture		
I.	Without moisture.	20 minutes.	0 %
II.	1 % Moisture.	20 minutes.	3 %
III.	3 % moisture.	20 minutes.	5 %
IV.	5 % moisture.	20 minutes.	10 - 15 %
V.	7 % moisture.	20 minutes.	12%
2.	Total feed with step wise moisture		
I.	1 + 2 / 2 + 1.	20 minutes.	8 %.
3.	Stepwise feed with step wise moisture		
I.	1 Kg - 50 ml - 5 minutes	25 minutes.	33 %.
4.	Total moisture with step wise moisture	20 minutes.	45 %.

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