Mechanized Balling Disc Machine (Pelletizer) for Industrial Development in Nigeria

Ikebudu Kingsley Okechukwu

Abstract - The aim of this project is to design and construct a balling disc machine for the production of balls /agglomerates pellets from a mixture either in its powder or molten form. This idea came up during the process of producing agglomerates pellets for the purpose of strength measurements of powder agglomerates balls/pellets for good handling of powder materials for consumption/usage and or during transportation. The machine consist a mixer. At the end of the construction of this machine it was tested for good performance. When this machine was tested as the balling disc speed was employed as required. Each pellets diameters were determined by averaging the diameters measured in three directions at right angles to each other using a vernier caliper. At this stage, the pellets are ready for strength measurement or usage. The result showed good formation of agglomerates balls / pellets diameter from 6 - 25mm while the capacity of production is from 30- 33t/h. This machine is mainly found in production industries, railway / coal corporations and steel industries.

Keywords: Balling disc, pelletizer, balls - pellets, glomerates, vernier caliper.

I. INTRODUCTION

A balling disc machine also known as pelletizing machine is a specialized equipment It is used for pelletizing of powder materials into balls/pellets of agglomerates. It is original and peculiar with large-scale disc-pellet machine and designed on the basis of the large-
scale disc-pellet machine that is used in industries like iron and steel industry, chemical industry, pharmaceutical industry, cement industry, ceramics industry, railway corporations, seen in metallurgical workshops and some related industries.

This machine adapts to pelletizing many kinds of powder material provided it is mixed with a particular solvent. The rotation disk is automatic and raw material collection and granulating capacity will be higher. The disc balling machine is used in the balling granular used to make damp granule into antique pellets. [1] – [3]. It is equally used in the pelletizing and alkaline leaching of powdery low grade zinc oxide ores [4]. It is also used in the mines.

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Disc balling granulator is suitable for mixing material pelletizing equipment with nutrient [5].

It has the following advantages:
(1) High balling rate
(2) Big roundness intensity of particles
(3) Visual operation and easy for maintenance.

They are of different kinds and forms ranging from its sizes, shapes, method of operation (manual or automatic), capacity, function, etc

Types of Pelletizing Machine

1. Balling disc machine: Balling disc machine is mainly used for production of balls and agglomerates pellets.
2. Floating feed pellet machine: This type of pelletizing machine is used for production of feed for animals.
3. Wood pellets machine: This type of pelletizing machine is used for making pellets of wood, plastics etc.
4. Biomass pellet machine: This type of pelletizing machine is used for producing pellets from biomass.

Pelletization

Pelletization[6] is the unit operation of producing larger bodies from fine powders so as to alleviate many of the problems associated with fine particulates, for example, some of the benefits provided by pelletizing coal include;
(1) Improved fugitive dust control
(2) Decrease in transportation costs and losses
(3) Reduced risk of spontaneous usage

Pelletization Of Powdered Coal

There are four ways of handling coal through pelletization and they are
(1) Briquetting
(2) Nodullizing
(3) Sintering
(4) Pelletization

Only partial understandings of the fundamentals of powder coal pelletization exist in this project.

In this project, I attempted to produce coal pellets with a balling disc machine and determined the diameters for compressive strength of coal for understanding of engineering material handling.

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Kerosene[7] was used as coal oil, solvent and as a binder. Binders[7] are used as additives to the material being pelletized. They can be classified into four types.

The first type is a matrix binder which is a solid or semi-solid, such as tar, pitch, asphalt, wax or cement. Another type is a film binder. These include water, solutions, dispersions, powders, silicate, gel, oil, alcohol, clay, starch. Chemical binders, the third type, react chemically with the material being agglomerated; these include silicate, acid molasses, lime and lignosulphate. And finally, there is a lubricant. The lubricant includes oil, glycerin, stearate and wax. Silicate can act as either a film binder or a chemical binder depending on what is being agglomerated, which property of silicate is utilized and the final properties desired in the agglomerate.

Pellets produced by this standardized technique are subsequently tested to determine its property with regards to the compressive strength of wet pellets or as the case may be.

Significance of the Research

Poor handling of coal has affected the iron and steel industries, Railway Corporation and coal industries. However, the contemporary balling disc machine is so expensive that some industries in Nigeria can not afford the price. With the design and construction of the mechanized balling disc machine to form pellets for crushing strength measurement or as the case may be, for good handling of powder material eg coal etc there will be improved fugitive dust control, decrease in transportation costs and losses, reduction in the risk of coal freezing and lowered risk of spontaneous combustion / usage[6].

Compressive Strength

The compressive[8] strength represents the resistance of the solid to compression, a property of paramount importance not only for industrial catalyst, but also for ceramics, pharmaceutical tablets and many other solid materials.

Compressive strength [9] is a maximum stress a material can sustain under compressive loading. The compressive strength of a material that fails by shattering fracture can be defined within fairly narrow limits as an independent property. However, the compressive strength of materials that do not shatter in compression must be defined as the amount of stress required to distort the material in arbitrary amount.

II. RELATED PROJECT WORKS

Omenyi, Fouda and Capes[10] studied on some surface energy effects in the strength of moist polymer agglomerates and obtained the compressive strengths of agglomerates made by tumbling cellulose acetate butyrate powders wetted by water-methanol solution of various concentrations. After normalization for the effects of variable pore saturation and porosity, agglomerate strength factors were plotted and found to exhibit minima as methanol concentration was increased. These minima also corresponded approximately to maximum pore saturation by wetting the liquid. It was proposed that these experimental maxima and minima corresponded to a condition under which surface tensions of the liquid and solid phases were just matched, so that maximum capillary suction and zero van der walls forces of attraction existed in the wetted particle systems. It was concluded that reliable solids surface tension data could thus be generated from compressive strength measurements on agglomerates of low energy particulate solid.

III. THEORETICAL ANALYSIS

Considering the single phase induction motor with a speed of 400rpm, having a power of 1800kw, the diameter of the shaft from the motor is 20mm.

To calculate the angular velocity of the motor;

$W=2\pi N\div 60$

$= (2\times 3.142\times 400) \div 60$

$W=41.89/sec$

To find the actual torque of the motor

Torque (T) = P/W

Where $P=1800\times 1000$

$W=41.89$

$T=1800\times 10^3\times 1000/41.89=42969.7KN/m.$

Again to calculate for the torque transmitted

$T=P \times 60/2\Pi n$

$T=1800 \times 1000 \times 60/2\pi\times 400$

$T=108000000/2513.3$

$T=42971.835N/m$

IV. CHALLENGES/SELECTION OF MATERIAL

One of the basic factors that affect the choice of a project is the availability of materials, selection of materials, and the cost of the materials for the design or fabrication of the project. The materials selection for the design function depends on the following;

- The availability of these materials in our local markets.
- The strength of these materials
- The cost of these materials
- The possession of simple mode of the operation
- The appearance of these materials
- The ability of these materials to serve the purpose for which the project is intent to be designed.

Material

Metallic gears
Electric motors (single phase)
Angle iron

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Stainless Disc (25 cm)
Fasteners (bolts and nuts)
Washers
Shaft
Vibration Pad
Cream hardeners
Citizen gloss paint (army green)
Hand grinding machine
Hand drilling machine
Welding machine
Sand paper
Chisel
Hammer
Scriber
Try square
Bench vice
Hack saw
Flat file
Hand Glove
Welding goggle

V. KEY DESIGN

The key[11] is made of mild steel used in the locking of the gear to the motor shaft. It was inserted between the shaft and the hub of the gear acting as the pulley to connect both the gear and the shaft together in other to prevent relative motion between them. It was inserted parallel to the axis of the shaft. The name of the key used is square sunk key.
Mathematically,
W = T = D/4.
Where,
W = width of the key
T = Thickness of the key
D = Diameter of the key

D = 20mm
W = T = 20/4 = 5mm

NB: A key way which is a slot or recess in the shaft from the motor and the hub of the gear acting as the pulley to accommodate the key made.
Basically keys are used as temporary fasteners and subjected to consider crushing and shearing stresses.
Also note that during the design of the key, forces due to fit of the key where neglected and it was assumed that the distribution of forces along the length of the key is uniform.

Now owing to the fact that L x W x T x d/2 = L x t/2 x бc x d/2
w/t = бc/2T
where, W = width of the key
T = Thickness of the key
бc = crushing stress of the key
ĩ = Shearing stress of the key

Therefore the key used is equally strong in shearing and crushing. Know that the key material and shaft material are the same.

To find the speed of the driven N2
From T2 = N 1T 1/N2
N2= N1T1 /T2
Where,
T1=no of teeth of drivers = 24
T2=no of teeth of driven=24
1= speed of driver =400
N2= speed of driven=200

Mean speed = 400 + 200/2 = 300rpm
N=300rpm
N2 = 400 × 24/24 = 400rpm
N = 300 × 24/24 = 300rpm
Therefore, if N1 =N2
T1 = T2
This means that gears transmits equal amount of speed. The name of the gear is spur gear, with 50mm diameter as pitch circle.

Dp = mTp
To find the modulus
50/24 =m
M=2.08

Step Turned Shaft Design
The shaft used is called a transmission shaft. Now assuming the allowable shear stress as 42mpa the line shaft is rotating at 400rpm and transmitting 18kw.
To find the diameter of the shaft
$T = p \times 60/2\pi N = 18 \times 10^3 \times 60/2\pi \times 400$
$=429.69 = 430$ N-m or
$= 430 \times 10^3$ N-mm
But $T = \pi/16 \times \tau \times d^3$
$430 \times 10^3 = \pi/16 \times 42 \times d$
$430 \times 10^3/16 = \pi\, 42d^3$
$203.65 = d$
$d = 5.8$mm

NB: we assume 20mm diameter of the shaft because of its rigidity and loading.

VI. METHODOLOGY

The Marking out process
The first stage of this fabrication was the marking out of the required dimensions of the sheet metal and the angel iron together with the square iron bars[12].

The cutting process
The second stage after the required dimensions were marked out was the cutting out of the required length from the main material. The cutting out was done on the vice with the aid of a hacksaw.

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The welding process
After the first two processes were carried out, the materials were joined together by means of the joining process called "WELDING". This involves the welding of the various parts of the frame together using the electric arc welding process.

The boring process
After the welding process, holes were bored into the frame to accommodate the bolts and nuts that would be used to fasten the machine parts together.

The coupling process
This comprises the coupling of the various parts of the machine which include the induction motor, the stainless pan, the shaft, the gear train.

Fig 1: The coupling process of the balling disc machine

The filler process
This involves the process of filling the various holes and uneven surfaces on the machine with a filler material which is strengthened by a cream hardener.

The painting process
This is the final process of the work which involves the painting of the machine surface with oil base paint. The painting was done with the aid of a spray painting machine.

VII. DESCRIPTION OF THE BALLING DISC ASSEMBLY

The marking out process, cutting process, welding process, Boring process, coupling process, filling process, Painting processes were done with the required precision. The joint parts of the Machine were fastened with the appropriate fasteners. During the assembling, a damper rubber was used to seal through the edges of the stainless pot including the cover to avoid material loss when the machine is functioning. Due to the vibration caused by the electric motor inside the machine when at work or in operation, the use of a vibration pad was introduced at the base to control and reduce the vibration effect of the machine.

At the end of the assembling operation metal casing was formed to encapsulate the machine itself to avoid the exposure of the skeletal parts. This metal casing was also used to make the machine fanciful and presentable. The metal casing equally provides support and stability to the machine which helps the machine to stand on its own without falling to any direction. This enclosure is perforated to aid cooling of the electric motor.

VIII. DIAGRAMATIC REPRESENTATION OF THE BALLING DISC MACHINE

Fig2: The front view of the balling disc machine

Fig 3: The side view of the balling disc machine

Fig 4: The rear view of the balling disc machine

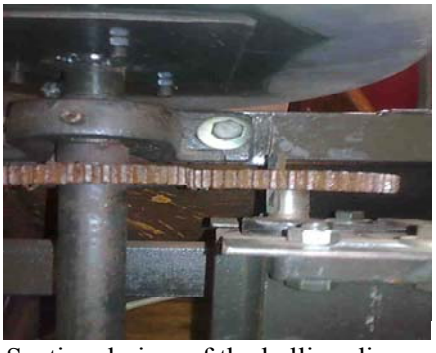

Fig 5: Sectional view of the balling disc machine

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IX. WORKING PRINCIPLE OF THE MACHINE

Testing the Machine

When material enters into a disc in a certain rotary speed, it is brought up to part of the inclined disc by the friction with the disc surface, as balling disc speed was employed as required where a certain quantity of some water was sprayed into the material (normally it is better of 8-9% moisture content in material) to make material form pellets; little pellets continually grow up to big one and form the pellets with specific size through repeatedly rotation and constantly adding material.

Agglomerates of different sizes of coal powder required for strength determination were formed using a balling disc of 25cm diameter with adjustable inclination of 45• to the horizontal. Each pellet diameter was determined by averaging the diameter measured in three directions at right angles to each other using a vernier caliper.

Fig 6: Plane view of the balling disc machine

Testing, Performance and Evaluation

The project when completed was tested in the mechanical engineering laboratory of Anambra State University, Uli, Anambra state. Electricity was used to supply power through the electric motor. The test was successful and the necessary formation of the pellets was done by the machine.

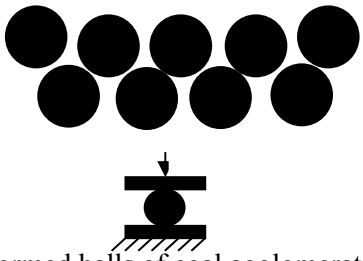

Fig 7: Formed balls of coal agglomerates pellets for strength measurements

The following are the results of the pellets in terms of the pellet diameter.

X. EXPERIMENTAL RESULTS

Table 1. Experimental Results

S/N	Coal sieve size(μm)	Range of Pelletized coal diameter(m)	Tormation Time (sec)
1	75 μm	10.00-40.00	3.27-9.80
2	150 μm	10.00-40.00	2.18-8.70
3	212 μm	10.00-40.00	1.90-7.50
4	300μm	10.00-40.00	1.17-4.70
5	425 μm	10.00-40.00	1.60-6.40
6	600 μm	10.00-40.00	1.40-5.50
7	850 μm	10.00-40.00	1.00-4.00

XI. DISCUSSION

From the result of the experiment performed, it is observed that the balling disc machine produced different sizes range 6-25mm of coal pellets.

The world grows daily in terms of engineering and technology. Virtually all the machines in the world today have risen from electrically operated to automatically operated. This advancement leads to an effort made on this project to practicalize a simple way of understanding the balling disc technique. The understanding of the balling disc technique is now one of the basic things a designer should know before embarking on designing any machine or manufacturing set up. Hence, it will be of greater advantage to engineering students and respective industries to adopt this balling technique because the world is so much depending on them. This machine, mechanized balling disc (palletizer) for industrial development in Nigeria has been designed, constructed, completed, tested and found worthy to help the affected industries and as a teaching aid for students of engineering to appreciate the manufacturing process being taught them in classroom lectures.

XII. SAFETY PRECAUTION

- Eye protection is a primary safety consideration around the machine shop. Machine tools produce metal chips and there is always a possibility that these may be ejected from the machine at a high velocity thereby causing serious damage to the body.

  Eye protector must be worn at all times in the machine shop. Several types of eye gadgets are available but in the course of carrying out the project work we used the plain safety glasses that are available in most shops to prevent the chips from flying into my eyes during the machining of the shaft.
- In as much as the machine shop does not present too great a hazard to the feet. However, there is always a possibility that something could drop on

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one's feet. That was why in the cause of the fabrication we ensured that we wore boots with steel toes as a shield to resist impacts, should a heavy object fall towards my foot.

- In an industrial production area or shop there is always a great level of noise due to the equipments used. we considered the noise level and tried to reduce it to the barest minimum with the use of ear and head helmet.
- As a result of the operation done with the grinding machine. It is only but usual that a lot of fine particle grinding dust mixed with metal particles would be produced. The grinding work done to smoothen out some parts of the machine was done in open area where there was rapid flow of air.
- In the cause of welding we made sure that we wore coveralls to protect skin from the fire sparks coming out due to welding.

XIII. MAINTENANCE

It is a well known fact and an act of responsibility to know how to care and maintain machine. Without this maintenance culture amongst us, there would be an unparallel waste of resources in order to procure new machines and whole lots of recyclable waste.

In the fabrication of the balling disc machine, the care and maintenance of the machine was highly considered and an easy maintenance culture was included.

The stainless pan was provided with holes in the base and attached to the shaft with bolts and nuts to ensure easy removal for cleaning. Various types and sizes of bolts, nuts and washers were used extensively throughout the system to ensure easy assembling and disassembling and to facilitate easy cleaning.

In the care of the gears, a reasonable amount of grease should be applied to the gear train so as to facilitate easy movement of the gear.

The wire connected to the electric motor to the power supply should be checked often to see if there is an internal snap in the wire or if the wire is about to cut.

The frame of the machine should be dusted frequently and should not be allowed to be exposed to water. The machine should not be used as an alternative to a seat. The machine should never be overloaded.

XIV. RECOMMENDATION

This machine has been designed, fabricated and tested. It is working effectively and conveniently. The project is of benefit and as a teaching aid. Consequently, from this benefit, the machine is recommended to manufacturers for usage.
More importantly, this machine is recommended to scholars for further research and improvement.

XV. CONCLUSION

The result of the balling disk machine showed good formation of agglomerates balls / pellets diameter from 6 - 25mm while the capacity of production is from 30-33t/h.
Basically, it is seen mostly in industries like iron and steel industry, chemical industry, pharmaceutical industry, cement industry, ceramics industry, railway corporations, seen in metallurgical workshops and some related industries.

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