Design of Dolomite Crushing and Grinding Plant

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***Abstract*— Dolomite, a calcium magnesium carbonate of chemical formula $CaMg(CO_3)_2$ is a rock forming mineral commonly found in India, Canada and Africa.This paper explains design of 15 t/hr plant for dolomite processing by discussing process flow and size reduction. Equipment required for crushing, grinding, material handling and filtration are selected based on available design inputs and intended output parameters.**

***Keywords*— Dolomite, Crushing, Grinding, Material handling, Filtering**

I. Introduction

Dolomite is a saddle shaped crystal which most likely exists in sedimentary or metamorphic rocks. Alternativelyknownas dolostone. Dolomite finds its application inmanufacturing, chemical and agricultural industries as a metallurgical flux, a source of magnesia and a soil conditioner. Other applications are pH level buffer, ornaments and building particle detectors [1].

According to government survey(2013-14), in India dolomite production is concentrated in Chhattisgarh and Andhra Pradesh accounting for 36.5% and 19.37% of total productionrespectively [2]. Our motivation to design this plant is fuelled by the fact that this design will help in building similar plants in other parts of the country to increaseproductionfor derivative products. Current solution to installing a plant elsewhere is to visit already present plants and study them. To avoid this hassle, better solution would be to have aneasily accessible plant layout with technical specifications of equipment involved.The application of dolomite output from this plant is manufacturing of wall putty which requires the size of dolomite powder particles to be as fine as possible. Assuming, 15t/hr production of dolomite powder is required to satisfy the input demand for wall putty production.

The plant layout being discussed has the following input-output characteristics-

TABLE I
Characteristics of Input [3]

Sr. No.	Description	Details
1	Input Size	<300 mm
2	Molecular Weight	184.40 grams
3	Specific Gravity	2.8
4	Density	2840 kg/m^3
5	Moisture	8%
6	Temperature	Normal

TABLE II
Characteristics of Output

Sr. No.	Description	Details
1	Output Size	0.053mm
2	Output Sieve	270 mesh
3	Moisture	<4%
4	Appearance	Powder
5	Temperature	Normal
6	Residue	Below 0.5%

The design approach followed in this study involves-
1. Planning the sequence of equipments
2. Dividing operations into stages to reduce work load on machines
3. Ensuring processing steps are carried out efficiently by introducing checks and loops after crushing and grinding equipment
4. Providing filtering equipment for ecologically safe discharge whilst following government norms for air pollution
5. Calculation of key specifications and selection of appropriate equipment.

The software AutoCAD 2016 (Student Version) is used to draw the size wise process layout for pictorial representation.

In section II, process flow is explained with an illustrative diagram.Section IIIshows size wise flow along with elaboration on design parameters involved and equipment selection.

II. Process Layout

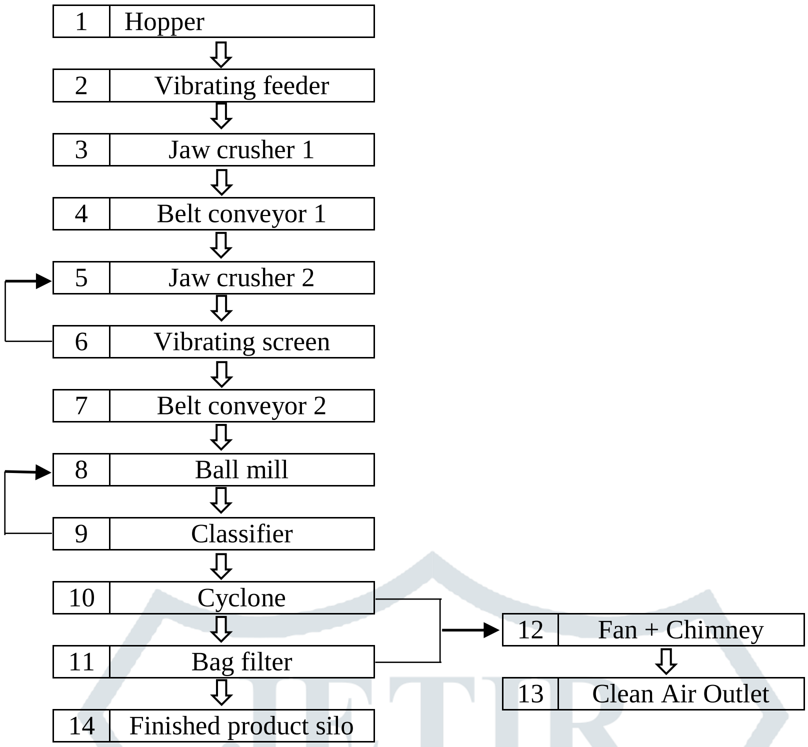

Fig. 1 Process Flow Block Diagram

Process flow block diagram is a pictorial representation describing the flow of material and the relation between each equipment. For highly productive crushing and grinding dolomite, we have designed a process flow which consists of material storage, material handling and material processing equipments.

The process is initiated by allowing the input raw material into hopper which aids in temporary storage of material and directs the material towards the vibratory feeder. The plant at this stage deals with heavy rocks and hence a rugged vibrating feeder is preferred automation to carry forward the rocks to the first stage of crushing at the jaw crusher-1. The jaw crusheris one of the vital equipment capable of one-fifth size reduction. To obtain substantial change of rock size and to accommodate ball mill input constraints, the process demands a second stage of crushing at jaw crusher-2. The output of jaw crusher-1 is then passed on to Jaw crusher-2 via belt conveyor-1. A vibrating screen is placed after the jaw crusher-2 to filter out over-size material and a backflow is setup from vibrating screen to jaw crusher-2 toreprocess the same. With the help of belt conveyor-2 thescreened appropriate size material is sent to ball mill [4].

Ball mill is the last material processing machine required due to its high size reduction ratio.It carries out grinding operation to reduce the small rock formations into fine powder with the help of steel balls. To keep a check ifthe output from mill is within limits, a classifier is used to separate out material which is above desired size and a backflow is setup from classifier to ball mill to reprocess the same. The output of appropriate size from the classifier is then sent to the cyclone separator which helps removing particulate matter from air streams through vortex separation. A bag filter is used to aid cyclone in dust collection and to comply with the government norms of pollution control. Cyclone and bag filter are both operated with the help of the induced draft fan which releasesthe clean air via chimney while the collected dust is blocked in the filtering equipments.The processed dolomite powder after passing through the cyclone and bag filter isstored in silos for further use [4].

III. Process Equipment

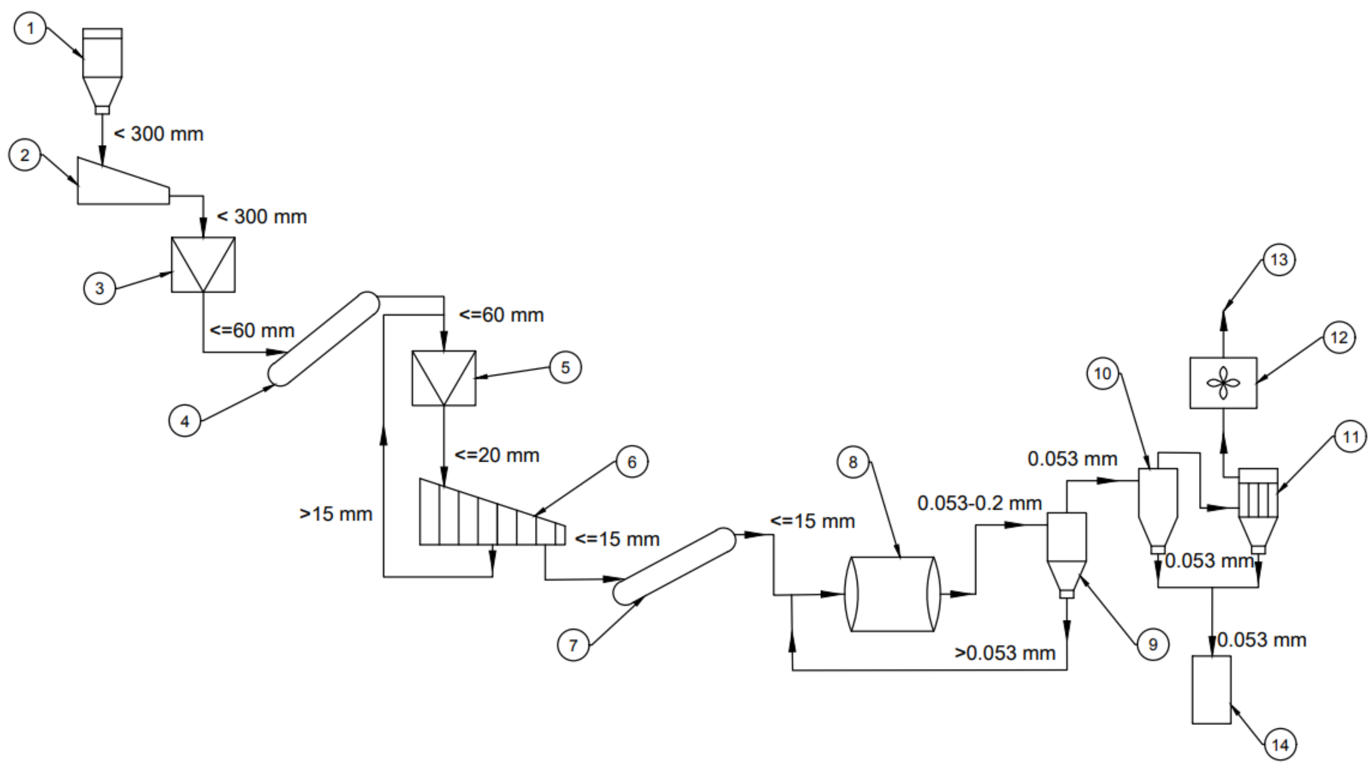

Fig. 2Size wise Process Flow Diagram

*The symbols used in the figure are only for representation purpose and do not relate to any standard

1. Hopper

The input size of dolomite, which is less than 300 mm, is departed through hopper for gradual feeding of material. For the flow of material in the conical section of hopper a 45° slopeis designed and total height to inlet diameter ratio is assumed as 1.25. Considering 5-ton capacity for every 20 minutes, the following parameters are computed: [5]

Height of bin	: 1500 mm
Height of conical section	: 440 mm
Total height	: 1940 mm
Inlet diameter	: 1200 mm

2. Jaw crusher 1

Jaw crusher drastically reduces the need of other heavy-duty machinesin process flow. As the name states, it is used for crushing material. Reversible jaw liners are mounted on both sides and held responsible to reduce the input of less than 300 mm to 60 mm or less as the reduction ratio is 1:5[6]. A jaw crusher of weight 6 ton with a feed opening of 600 mm * 375 mm is selected. Power required by motor to drive the machine is 27 KW [7].

3. Jaw crusher 2

Use of anther jaw crusher in the process significantly decreases load on grinding machine. The working principle is same as jaw crusher-1. The difference lies in the power consumption and area occupied because of less working load as compared to jaw crusher-1. Maximum size of input to this jaw crusher is 60 mm and the desired output is less than or equal to 15 mm. It has a feed opening of 400 mm * 225 mm and a total weight of 3 ton with motor power of 19 KW [7].

4. Vibrating screen

Vibrating screen uses vibration for screening of material into different sizes using sieves. For vibrating screen,feed size is less than or equal to 20 mm. Particles of dolomite which are less than or equal to 15 mm are desired after screening. For design of screening areaand capacity calculation for single deck screen with square opening, key assumptions are: [8]

2/3rd of the feed is less than 15 mm.

25% of feed is over-size and 40% of feed is half-size.

Screening efficiency is 90%.

Using the values obtained from the above assumptions, we select a screen from manufacturer's catalogue with specifications:

Slope range	: 18-25
Nominal speed	: 850 rpm
Area of screen	: 3.6m^2
Power required to drive screen	: 2*1.9 KW
Capacity	: 40TPH

5. Belt conveyors

Belt conveyor comprises of two or more pulleys and an endless belt of carrying medium that rotates around them. Considering angle of surcharge as 25° and slope of conveyor as 20°, a plain belt which has nylon on top and bottom layers is taken [3].

Belt conveyor has following characteristics: [9]-[10]

Effective width	: 850 mm
Power	: 5 HP
Belt speed	: 2.5 m/s
Rating	: 800/3
Belt tension	: 80 KN
Number of idlers for troughed belt	: 3
Angle of idlers with horizontal	: 30°
Nominal carcass thickness	: 5 mm
Minimum pulley diameter	: 400 mm

6. Cyclone

A cyclone separates particulates from air, gas or liquid stream without the use of filters, through vortex separation. Assuming the inlet velocity as 3600 FPM, inlet area of 2.45 ft^2 is calculated for a given air volume of 8828.26 ft^3/min. For this requirement, single cyclone model 245 VM 700 150 can be selected [11].

To optimize space occupied and to achieve greater efficiency, a quad cyclone with inlet velocity of 4000FPM is selected. It includes 4 smaller sized single cyclones grouped together to perform the same tasks as that of a single cyclone. The overall size of the quad cyclone, whose diameter is 20 inches, fits in a space with dimensions 1.09m * 1.397m.The quad cyclone model selected has nomenclature as 4 240 VM 700 140 [11].

7. Bag filter

Bag Filter, also known as fabric filter is an air pollution controlling equipment which works as a dust collector.Based ongas volume of 15000 m^3/hr, total filter area of 70$m^2$is calculated. 64 bags of 10 ft length are accommodated in the available filter area to carry out filtration at the rate of 3.54 m/min. Square shaped bags are selected to withstand design pressure of 20 inchesof water gauge. Themodel of bag filer selected has nomenclature 64S 10 20 [12].

IV. Conclusion

In this paper, a plant layout with required technical specifications was suggested for a capacity of 15t/hr. The major findings are as follows:

- → Two stage crushing is required to reduce load on grinding operation
- → Vibrating screen is essential before ball mill to obtain proper size reduction
- → Classifier is essential after ball mill to ensure 0.053mm size powder is obtained

The limitation for the proposed design is that it is restricted to installation of 15t/hr capacity plant and this plant is not capable of accommodating any increase in capacity requirement. Increase in capacity may lead to increase in number of stages of operations and changes in the sizing and specification of equipment.

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