Design & Development of Wet Ball Mill (WBM) for Flue Gas Desulfurization (FGD)

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Abstract - Flue Gas Desulfurization is a technique for reducing sulphur emissions, which cause acid rain. When fossil fuels are burned, large amounts of gaseous sulphur oxides are released into the atmosphere. Sulphur dioxide is a serious pollutant that has a negative impact on human health. Sulphur dioxide concentrations in the atmosphere can have an impact on the flora and wildlife. Furthermore, SO_2 emissions serve as a precursor to acid rain and airborne particulates. Particulate matter is made up of very minute solid particles and liquid drops that contribute to the smoky look of exhaust gases. SO_2 is removed from flue gas in practically all FGD systems by reacting with an alkaline material to create sulphite or sulphate. The contact method is used in the FGD process.

***Key Words*:** FGD, Wet Ball Mill, Limestone Grinding, Sulphur Dioxide removal, Slurry, Gypsum, etc.

1. INTRODUCTION

Sulphur dioxide (SO2) is removed from flue gas emissions by a chemical process called flue-gas desulfurization (FGD). Sulphur dioxide is created in gases as a result of the combustion of fossil fuels and a variety of industrial processes such as cement, paper, glass, steel, iron, and copper manufacture. Sulphur dioxide emissions are a major cause of acid rain, and they are restricted in every industrialized country on the planet. The amount of SO2 involved, the solution used to absorb the SO2, and the specific equipment utilized in the absorption tower all influence the FGD process.

Sulphur dioxide in flue gas from fossil-fuel power plants and emissions from other Sulphur-oxide-emitting operations can be regulated using a method called flue-gas desulfurization. SO2 is removed from flue gases using a variety of techniques, the most prevalent of which are:
• Wet scrubbing with an alkaline sorbent slurry (typically limestone, lime) Alternatively, saltwater can be used to cleanse gases.
• Scrubbing with identical sorbent slurries during spray-drying.
• Sulphur is recovered in the form of sulphuric acid in a wet sulphuric acid process. sulphuric acid of commercial purity.
• SNOX flue gas desulfurization, which removes sulphur dioxide and nitrogen from the flue gas particles and oxides from flue gases.
• Injection systems for dry sorbents.

In a wet ball mill, a hollow cylindrical shell revolves around its axis. The axis of the shell can be horizontal or slightly inclined to the horizontal. It is partially filled with balls. The grinding media are the balls, which can be made of steel (chrome) or plastic. Some of the materials that can be used are steel, stainless steel, ceramic, or rubber. An abrasion-resistant substance, such as manganese steel or rubber, is typically employed as a liner for the cylindrical shell's inside surface. Mills with rubber linings last longer. The mill's total length is approximately equal to its diameter. The outcomes are the same whether the grinding is done wet or dry. The former is done at a leisurely speed. Many power plants and industrial establishments use flue-gas desulphurization (FGD) scrubbers to remove SO_2 and SO_3 from combustion gases.

2. PROBLEM STATEMENT

SO_2 emissions have been linked to negative effects on human health and the environment. The most serious health risks connected with exposure to high ambient temperatures are breathing difficulties, respiratory sickness, and aggravation are all symptoms of high SO_2 levels. One of the most commonly utilized SO_2 procedure is absorption of flue gases by a slurry containing $CaCO_3$ used to remove the SO_2. Existing systems are built for large-capacity boilers and thermal power plants, and they have a low absorption rate. Better solutions are required to meet the EU's severe environmental protection rules for SO_2 emissions. The project's goal is to focus on current issues and successes in gas desulfurization in order to assist in determining the right direction of efforts for developing a new technology as well as the selection of apparatus and equipment.

3. OBJECTIVES

The primary goal of this project is to manufacture a Wet Ball Mill that can grind limestone specimens into a slurry.

The project's aims are as follows:

- Selection and analysis of the Material Inlet Support structure (channel frame).
- Replacement of Anti-Friction Bearings in place of Bush Bearings for Ball Mill Pinion Shaft Assembly.

4. SCOPE OF THE PROJECT

During the projected period of 2020-2025, the flue gas desulfurization (FGD) market is expected to develop at a CAGR of about 4.80%. Flue gas desulphurization demand is expected to rise globally as people become more aware of air pollution as a result of global warming and environmental deterioration. The industrial downturn in several of the major regions, such as Asia-Pacific and North America, is, however, putting a brake on the flue gas desulfurization market.

Concerns about environmental contamination and government measures to combat it are driving the growth of the FGD industry. The Clean Air Act (CAA) and the Mercury and Air Toxics Standards, for example, mandate power producers who use fossil fuels to install technology that monitors and reduces emissions to a safe level.

5. METHODOLOGY

The limestone slurry preparation system, which includes a wet ball mill circuit for limestone grinding, is a part of the FGD (Flue Gas Desulphurization) facility. Coal is being used to create electricity at the power plant. During the complete combustion (coal burning), flue gas is created, which generally releases Sulphur Dioxide into the atmosphere. A flue gas desulfurization (FGD) system uses limestone slurry as the reagent to reduce the amount of Sulphur dioxide in flue gas before it is emitted into the air. The three main subgroups of the FGD system are the limestone slurry preparation system (i.e., Wet Ball Mill System), the Sulphur Dioxide Absorption Tower (FGD) system, as well as the Gypsum de-watering system (Vacuum Belt Filter).

Project work includes;

- Design, calculation & selection of Channel sizes for the material inlet support.
- Anti-Friction Bearings to be used instead of Bush Bearings for Ball Mill Pinion Shaft Assembly.

5. LITERATURE REVIEW

Flue gas desulphurization wet limestone-gypsum process, KC Cottrell Co., Ltd.

This literature goes through the wet FGD technique in great detail. In a wet scrubbing process, the Moretana Plate and magnesium hydroxide (Mg(OH)2) or sodium hydroxide (Na(OH)2) are utilised. NaOH is responsible for more than 51% of the Japanese market and 90% of the global market. The Taiwanese market is one of the world's most active. It has a proven track record and uses Mg(OH)2 or Mg(OH)3. Flue gas from boilers is circulated with NaOH solutions to remove SO2 and particles. Encounters with fluids increasing the pH can help to improve the effectiveness of SO2 removal and the SO2 2-levels in the sorbent the higher the pH level, the sharper the pH decline.

Closed Circuit Grinding VS Open Circuit Grinding

The simplest basic grinding circuit is a ball or rod mill in closed circuit with a classifier. When a product finer than 65 mesh isn't required, this single-stage circuit is commonly used for coarse grinding; however, it can be converted to fine grinding by replacing the straight classifier with a bowl classifier to keep the W/S ratio of the overflow below the 4/1 limit required for flotation. Because of its better efficiency, the bowl classifier is increasingly being used in facilities that grind up to 65 mesh.

Because of its simplicity, single-stage grinding is often used for small plants. In most plants, variations in the size and character of the ore are unavoidable, although they are typically far more evident when activities are on a small scale than when they are on a big one. As a result, multi-stage grinding as practiced in big installations may prove challenging to control on a very small scale, and the simplicity of single-stage grinding is likely to result in a higher overall efficiency than a multi-stage system.

Ball Mill Working Principle & Methodology

Ball mills are used to grind materials such as coal, pigments, and felspar for pottery. Wet or dry grinding can be done, however the former is done at a slower speed. Wet grinding has a number of advantages, including reduced power consumption (20-30 percent) compared to dry grinding, increased throughput, and a reduction in the formation of fines/dust, making it easier to remove the product and preventing the formation of dust. The Wet grinding has several disadvantages, including the requirement to dry the product and high machine wear. The material used to grind (about 20 percent higher as compared to dry grinding).

When selecting the proper combination, consider the following factors: power requirements, gear ratings, floor space, interference from other plant equipment, and motor characteristics. The most prevalent categories are described and illustrated in this section.

FGD - WET BALL MILL ASSEMBLY

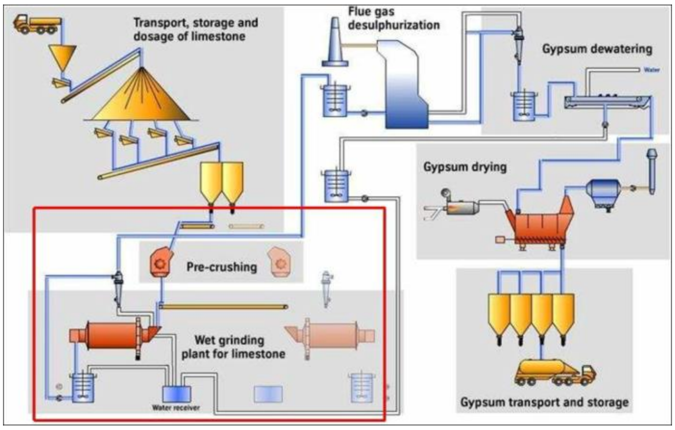


Fig -1: FGD (Flue Gas Desulphurization) Process Overview

Following processes are involved in FGD Wet Grinding;

- Transport, storage and dosage of limestone
- Pre-crushing of limestone
- Wet grinding plant for limestone
- Flue gas desulphurization
- Gypsum dewatering
- Gypsum drying
- Gypsum transport and storage

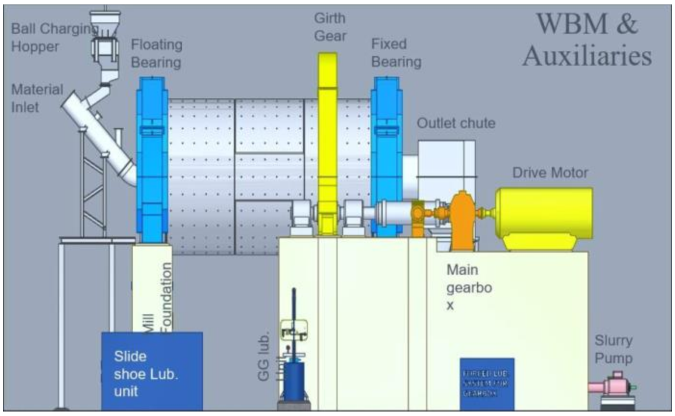


Fig -2: Components of Wet Ball Mill

Wet Ball Mill has following main components;

- Mill Inlet & Outlet
- Mill shell & Mill Rubber Lining
- Mill bearing assembly (Slide shoe bearing arrangement)
- Girth gear assembly
- Pinion shaft assembly
- Mill Discharge Chute
- Ball charging hopper assembly
- Mill drive Unit and Foundation

FE Analysis of material inlet frame for actual & reduced channel size

Material inlet chute supported by channel frame. Initially, ISMC100 channels are used for support frame. For analysis purpose, we have considered ISMC75 channels.

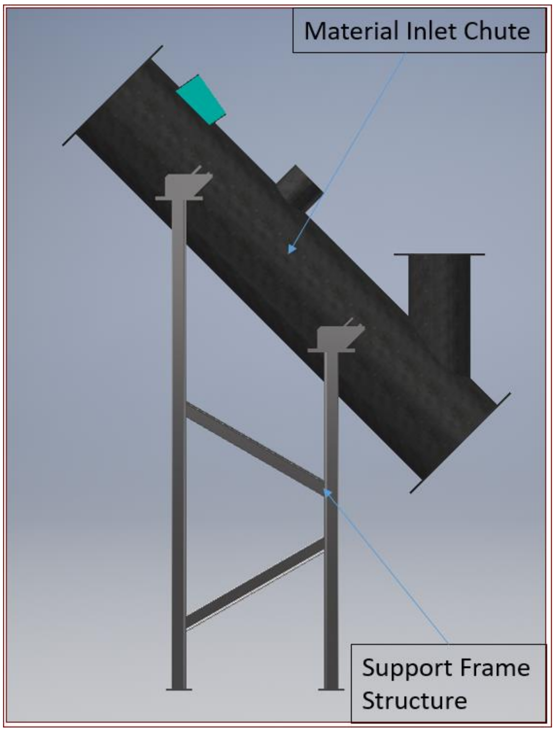


Fig -3: Material Inlet Chute with support frame

Inputs for FE analysis;

Plate Area	= 0.035 m²
Pressure on plate	= 0.367 Mpa
Total Load on frame	= 51380 N

Following are the analysis values for Inlet Structure,

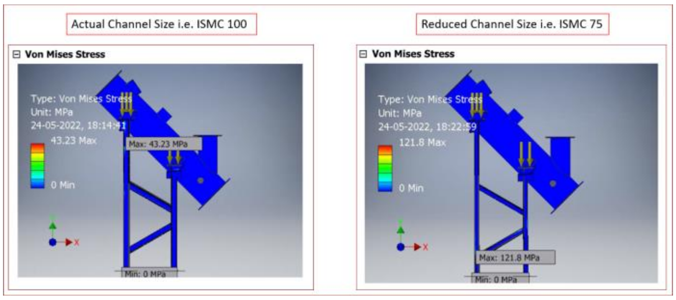


Fig -4: Von-Misses Stress of Actual & Reduced channel size

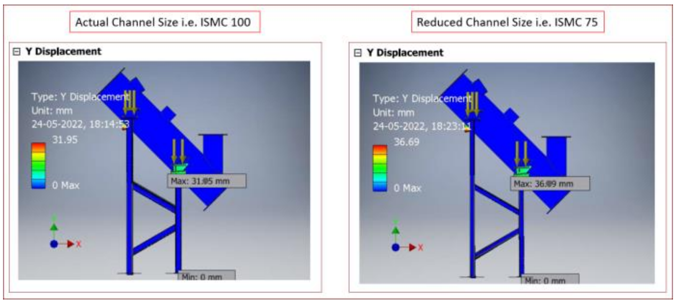


Fig -5: Displacements of Actual & Reduced channel size

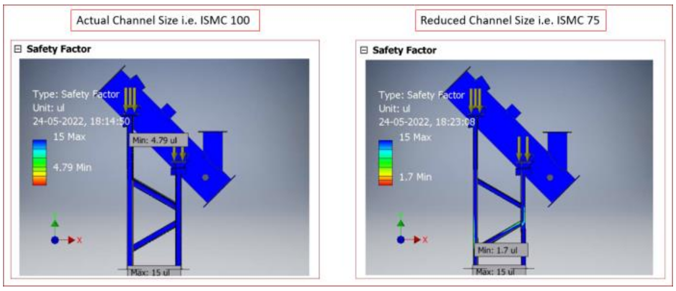
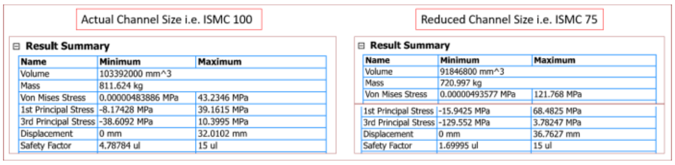


Fig -6: Safety Factor of Actual & Reduced channel size



Actual Channel Size i.e. ISMC 100

Result Summary

Name	Minimum	Maximum
Volume	103392000 mm^3	
Mass	811.624 kg	
Von Mises Stress	0.00000483886 MPa	43.2346 MPa
1st Principal Stress	-8.17428 MPa	39.1615 MPa
3rd Principal Stress	-38.6092 MPa	10.3995 MPa
Displacement	0 mm	32.0102 mm
Safety Factor	4.78784 ul	15 ul

Reduced Channel Size i.e. ISMC 75

Result Summary

Name	Minimum	Maximum
Volume	91846800 mm^3	
Mass	720.997 kg	
Von Mises Stress	0.00000493577 MPa	121.768 MPa
1st Principal Stress	-15.9425 MPa	68.4825 MPa
3rd Principal Stress	-129.552 MPa	3.78247 MPa
Displacement	0 mm	36.7627 mm
Safety Factor	1.69995 ul	15 ul

Fig -7: Result Summary of Actual & Reduced channel size

From analysis, values observed in case of reduced channel size are in within limits.
As this support frame is steady, we can use ISMC75 channels for inlet frame instead of ISMC100 channels.

Pinion Shaft Bearings – Bush Bearings are replaced with Anti-Friction Bearings

In FGD-WBM, we require two numbers of bearings for pinion shaft. For earlier projects, we have used Bush Bearings for the same. But, bush bearings have limitation in diameter range and difficult construction of bearing housing, that's why we have replaced anti-friction bearings instead of bush bearings for pinion shaft. Anti-Friction bearings have variety of range in diameters and it has simple design than bush bearings.

ROLLING OR ANTI-FRICTION BEARING

- Due to less contact area rolling friction is much lesser than the sliding friction, hence these bearings are also known as antifriction bearing.
- Frictional resistance considerably less than in plain bearings

ADVANTAGES OF ROLLING BEARINGS COMPARED TO JOURNAL BEARINGS ARE:

- Starting friction torque is about twice the running frictional torque, but still it is negligible in comparison to starting friction of a sleeve bearing (Sliding Bearing).
- Ease of lubrication either with grease or with relatively simple systems.
- Less axial space for a comparable shaft diameter.
- Capable of supporting both radial and thrust loads.

In some the ball mill projects, we have used bush bearings for pinion shaft.

Following is the drawing of Bush Bearing.

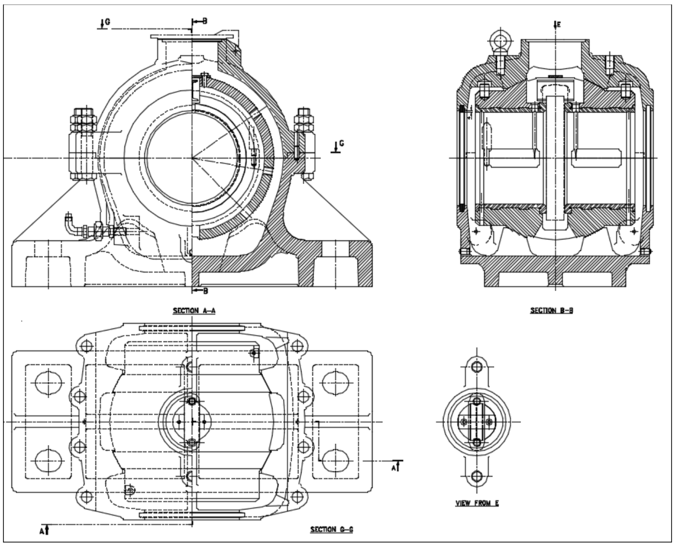


Fig -8: Bush Bearing for Pinion Shaft

- Bush bearing is generally used where a requirement of high speed and maximum possibility of corroding parts.
- Bush bearings are based on shrink fit or press fit by using interference between bush and hole to avoid seizure.

In recent ball mill projects, we have used Anti-Friction bearings for pinion shaft.

Following is the drawing of Anti-Friction Bearing.

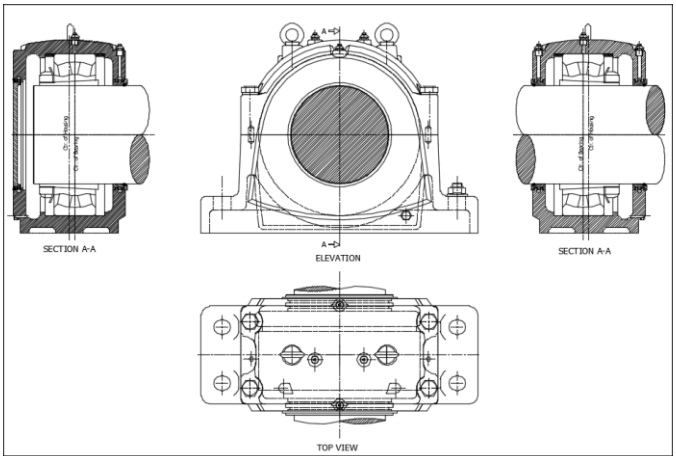


Fig -9: Anti-Friction Bearing for Shaft

- An antifriction bearing is a bearing that contains moving elements to provide a low friction support surface for rotating or sliding surfaces. Antifriction bearings are commonly made with hardened rolling elements (balls and rollers) and races.
- Anti-friction bearings are classified as either ball or roller types. Ball bearings use sphere shaped rolling elements whilst roller bearings use non-sphere-shaped rolling elements.

6. CONCLUSIONS

The wet FGD process of limestone / lime is the most extensively used method, according to literature, due to its strong desulphurization performance and cheap operating costs. Wet installations, on the other hand, are more efficient than dry processes. With a variety of formate additives, limestone use, and number of spray levels in the absorber, the same SO2 removal effectiveness (90 percent in this example) can be achieved.

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