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AUTOMATIC DIGESTER DOOR OPERATING SYSTEM

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Abstract - The product of KMML ltd is titanium dioxide which is the main constituent in tablets, pharmaceutical, paint and other paint related industry in our project we look into Ilmenite Beneficiary Plant (ibp), where the roasted, raw ilmenite containing 55-60% TiO is beneficiated to 92% TiO2 which is the raw material for the pigment production plant. The cooled, reduced ilmenite is sent to the digesters where it is leached with 18-20% HCl. During leaching, the ferrous oxide and other impurities are dissolved in HCL. The leached ilmenite is washed and calcined .The calcined product is beneficiated ilmenite

The digester is the main part of the IBP where the digester rotates for 20 hours for the process of leaching and it will take 15-20 minute for opening a single digester door with two men taking an immerse effort like hammering and jamming So there are different constraint problem like time wastage human resource management, delaying of the plant financial loss, low productivity, skin problems due to hcl exposure .A larger majority portion of the problems can be solved by our project, replacing the existing technology.

The proposal is the use of automatic digester door operating system where we introduce a hydraulic motor which is driven by a hydraulic circuit which is four way valve position to beat open the digester door or quick opening door by using a tee bar which is connected to the conveyor of the plant. Though the nature of the project dilute it is considered fine, satisfying by the authorities of KMML.

Key Words: digester door, kmml, operating system, roasting, dumping, hydraulic motor …

1. INTRODUCTION

Manufacturing Titanium Dioxide through the chloride route, KMML produces very pure rutile grade Titanium dioxide pigment. The different grades churned out by KMML under brand name KEMOX has a ready market which asks for more. The commendable, work in research by the R&D department has also helped KMML to add more colors to its portfolio.

KMML has always been responsive to social and environmental causes of the initiatives taken by KMML have made a significant change to the area and its people. KMML is now in the aerospace industry & Defense applications with the commissioning of the Titanium Sponge plant. The TSP is a joint venture of KMML, Vikram Sarabhai Space Centre (VSSC) and the Defense Metallurgical Research Laboratory (DMRL).

The VSSC has fully funded the Rs.143 crore TSP project. With the inauguration of TSP, India becomes the 7th country in the world having the technology for producing titanium sponge, which is the raw material for titanium metal.

Titanium sponge is known for its high strength but low weight, making it an ideal material for aircraft manufacture, including Figurehter aircraft. The material is also used in nuclear plants, Engine parts, Ocean platforms, Reactors, Heat Exchangers and to make dental implants and artificial bones paper.

1.1 IBP process Description

In ilmenite Beneficiation Plant (IBP] the raw Ilmenite containing 55 to 60 ° TiO2 is processed to obtain beneficiated Ilmenite of 90 to 9700 TiO2 which is the raw material for the pigment production unit, by the following process operations

1.2 Roasting

Raw Ilmenite is fed at the rate of 6.5-9 T Hr with 10% petroleum coke into a rotating kiln called Roaster. The ferric oxide in the raw ilmenite is first

Subjected to high temperature reduction to ferrous oxide in the presence of petroleum coke at a temperature of 900 to 950°C. The reduced Ilmenite is discharged through a rotary cooler having cooling water tubes and collected in a hopper..

1.3 Acid Leaching

Turn the digester with manhole straight upward.
Open the manhole by loosening the quick opening door mechanism and move the cover aside by means of overhead hoist. Care must be taken to protect the lining on from damage while placing on the platform placing. The digester may be rotated to charging position to fit the move, digester feed hopper.
After 4.2T of reduced ilmenite has been charged in the digester, rotate the digester in the reverse direction and bring the manhole up. Close the manhole with door and tighten.

2. Failures of digester door

2.1 Human hazards

When opening a digester for cleaning or repairing, workers will have high exposure problem of hazards gas that will affect the life of the workers. Making of frequent smell checks for gas leaks in plastic pipes, Joints, clamps, and gate valves is necessary Brass gate valves and pipes used in digester systems must be of a lead-free type. The hydrogen sulfide in biogas will destroy lead, which will cause gas leaks

When using any kind of gas, light the match first, then open the gas valve. If the valve is opened first and gas is allowed to flow without being lit for any length of time, large amounts of gas can escape and any flame might ignite a fireball.

The arrester can be a ball or roll of fine mesh copper wire (iron and steel would rust) inserted into the gas pipe. It is sometimes not realized that this forms a barrier to the free and full flow of gas According to occupational Safety and Health Act It is recommended that the flame arrester be placed in a length of pipe of slightly larger diameter than the gas pipe. For a 0.5 inch pipe use a 0.75 inch arrester pipe; for a 1.0 inch pipe use a 1.25 inch arrester pipe.

Failure to do so could result in dangerous, uncontrolled release of biogas and if the digester is a plastic bag, it could float up and away. An upside-down "T" pipe should be placed at the highest vertical point in the gas pipe line above the gas outlet from the digester. A vertical pipe and a gate valve should be joined to the stem of the upside-down "T" pipe. The gate valve can then be opened to release the biogas if a flood threatens to cover either the digester or the gas storage tank.

2.2 High Man power

Workers on the time of dumping and maintenance, will have to manually beat with hammer for the opening and closing of the digester mouth with the revolving door opener, very high manual effort is required

The revolving door opener is a heavy mechanical component. It is lifted using a hoist which is controlled by a remote and is placed in the required position manually for the opening or closing of the mouth.

The manual effort is applied on the tee bar provided on the top of the digester door. The torque is applied on this bar for the opening or closing of the mouth. Manual force is applied on the two ends of the bar to provide necessary torque

2.3 High delay and down time

It will take approx. of 10-15 min for the cool down to work on digester to provide human casuals and other hazards so after the cooldown only they can manually beat and open it.

So after the digester it is wasting a lot amount a lot of time considers for the acid leaching and pigments process so by introduction of the an automatic door we can stabilize the situation and make high efficiency and accuracy

3. New Digester Door Design operating Considerations

3.1 Hydraulic Retention Time

Hydraulic retention time (HRT) refers to the mean length of time that liquids remain in a digester. HRT, which often appears as θ in literature, can be calculated as the quotient of digester volume, V, and flow rate of a digester, Q : θ = V Q As a measure that is related to the loading rate, a shorter HRT corresponds to a higher loading rate. As such shorter HRTs are known to be associated with VFA acidification, which could bring in herbivory effects. Nonetheless, shorter [8]HRTs allow for increased process efficiency and decreased capital costs, although longer HRTs are necessary for the digestion of lignocellulosic wastes. Generally, mesophilic digestion can be accomplished within 15–30 days.

3.2Total Solids

Total solids (TS) is a measurement of dry matter in a sludge, irrespective of its organic or inorganic nature; it is often articulated in the literature as either a percentage or a concentration. The TS content is determined by the drying of a sludge sample at 103–105◦C in succession until no further change in weight is observed. Along with being an evaluation of influent, TS is an important attribute of digester operation. High-TS anaerobic digestion has received a considerable amount of recent attention, on account of its need for smaller digester sizes and lower heating needs. Furthermore, improved biogas yields were reported in continuous high-TS digesters compared to low-TS digesters operating on the same retention time.

3.3 Temperature

There exist two main temperature regimes for anaerobic digestion: mesophilic (35 ◦C) and thermophilic (55 ◦C). Because mesophilic digestion operates in a lower temperature, digestion at this temperature regime is slower and yields less biogas; however, mesophilic digesters remain attractive because of their lower heater energy costs compared to thermophilic digesters.

Thermophilic digestion, on the other hand, operates at a higher temperature. Consequently, reaction rates are increased, leading to a possibility of higher loading rates, in addition to increased biogas production. In addition, thermophilic digestion is known to have higher levels of pathogen destruction, which can prove useful in certain jurisdictions with regulations on pathogen activity in effluents.

At a digester temperature of 53◦C, a 90% decimation time of less than one hour was reported for several pathogens, while a 90% decimation time of several days was reported for the same pathogens in a digester operating at 35◦C. Some digesters are dependent on the ambient air temperature, requiring no heating; these digesters often see seasonal fluctuations in methane production. At the same time, research in unconventional temperature regimes has also been conducted, such as the use of Alaskan lake sediments in psychrophilic food waste digestion at−15◦C to +15◦C. 5. Pretreatments.

3.4Chemical Pretreatments

Acidic pretreatment is one form of chemical pretreatment, in which lignocellulosic substrates are broken down into their respective monosaccharides. Furthermore, the acidity associated with this kind of pretreatment can be adjusted to by hydrolytic

microorganisms. While acidic pretreatment is able to assist with the degradation of substrates in addition to reducing the time required for digestion, its costs render it less financially effective than utilizing alkaline pretreatments.

4. DESIGN OF NEW DIGESTER DOOR

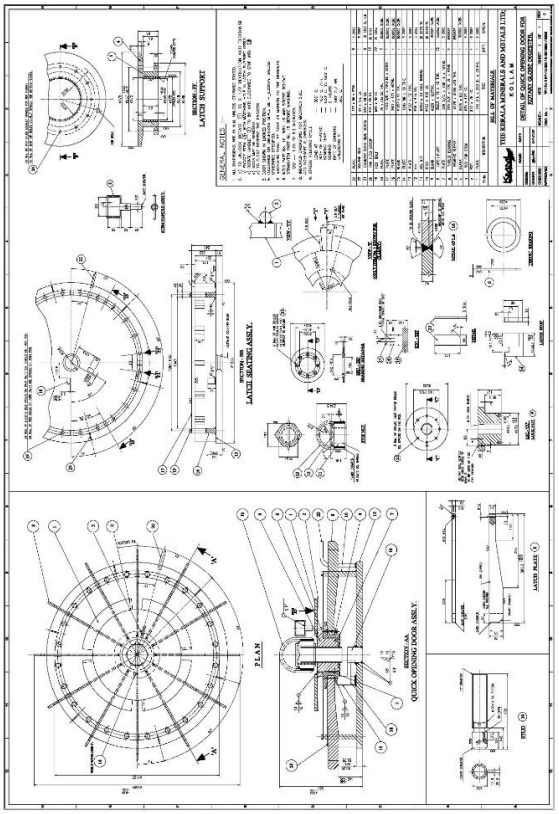

Figure1. Diagram of digester

The mouth of the spherical rotary digester in the Ilmenite Beneficiation Plant (IBP) is opened or closed with the help of a revolving door opener. For the opening and closing of the digester mouth with the revolving door opener manual effort is required.

The revolving door opener is a heavy mechanical component. It is lifted using a hoist which is controlled by a remote and is placed in the required position manually for the opening or closing of the mouth.

The manual effort is applied on the tee bar provided on the top of the digester door. The torque is applied on this bar for the opening or closing of the mouth. Manual force is applied on the two ends of the bar to provide necessary torque.

Digester door

[1]The digester door has latch plates which are initially arranged in radial direction. For the closure of the digester mouth, first the revolving door opener is placed on the top of the digester door in its required position and then latch plates [4] are placed. The digester door has provision for positioning latch plates and is done manually.

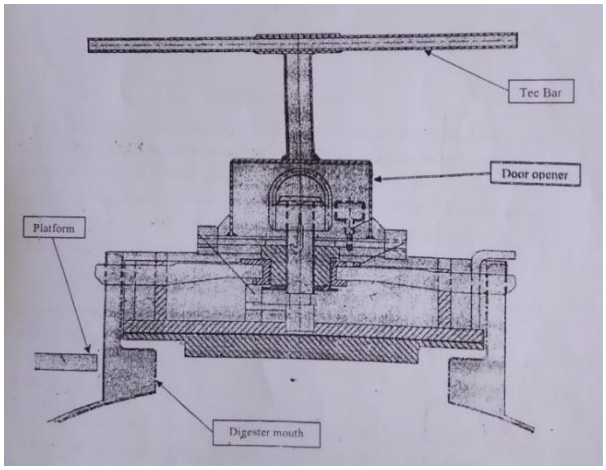

Figure 2. Design of new digester door

The mouth of the digester is provided with slots to accommodate the latch plates.
The latch plates are initially arranged in radial direction such that it connects the mouth and the door.
When the necessary torque is applied on the tech bar, the latch plates which are in a radial direction begin to straighten.
The plates will be loose initially and will be tight when the mouth is closed completely.
After closing the mouth, leak test is done to ensure that digester door proof and if not retighten the door or take rectification.
Assembly of revolving door opener on.

Hydraulic door opening system

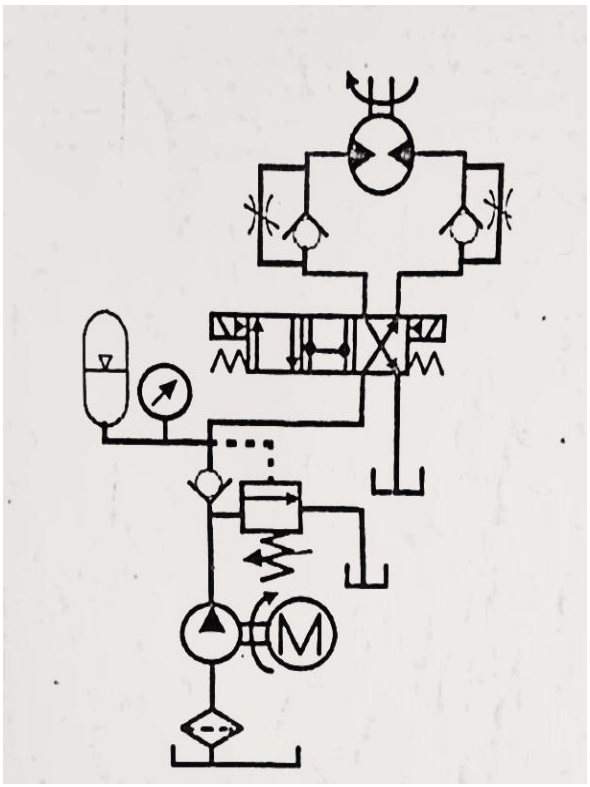

Figure3. Opening door system

The hydraulic door opening system consists of a hydraulic motor which [3] is driven by a hydraulic circuit as shown in the Figure. The motor drives a beater which strikes the tee bar of the revolving door opener.

This produces a torque necessary to operate the door. The hydraulic motor is fixed on a rigid frame and receives oil at high pressure from the accumulator. The accumulator stores energy and smooth out pulsations. It also reduces size of the pump required.

[2]The hydraulic motor is a bi-directional motor so that its direction of rotation can be reversed by a solenoid operated direction control valve. This beating action will produce necessary torque to operate the digester door.
The leverage of the bar reduces the load on the hydraulic motor and hence the motor required will be of low torque capacity. It also reduces the cost of the hydraulic motor.

The opening and closing of mouth manually requires large human effort and time. This can be minimized if this is done using a hydraulic system. The hydraulic system eliminates the need of human effort to provide required torque. It thus saves time and manual labor.

5. Bi-directional hydraulic circuit

The main components of the hydraulic circuit are

- Reservoir
- filter
- pump
- control valve
- pressure relief valve
- accumulator, directional control valve
- flow check valve
- Bi- directional hydraulic motor.
- Pressure control valve

One of the most important functions in any fluid power system is control. If control components are not properly selected, the entire system will fail to deliver the required output.

Bi- directional hydraulic motor

Bi- directional hydraulic motor fixed-and variable-displacement high-speed motors come in two frame sizes and four displacements for matching pressure and capacity. MFW model maintains constant torque with varying hp.

MVW model operates with constant [3]hp and variable torque or constant torque or constant hp.

They accommodate maximum pressure to 4500 psi, speeds to 3000 rpm, and theoretical maximum displacement from 0.86 to 2.83 in. ^{3} /rev

Figure. 4 Bi-directional valve

Actuators

A hydraulic actuator receives pressure energy and converts it to mechanical force and motion. An actuator can be linear or rotary. A linear actuator gives force and motion outputs in a straight line

Pressure Relief Valve

Schematic of direct pressure relief valve is shown in Figure 5 .This types of valves has two ports; one of which is connected to the pump and another is connected to the tank. It consists of a spring chamber where poppet is placed with a spring force. Generally, the spring is adjustable to set the maximum pressure limit of the system.

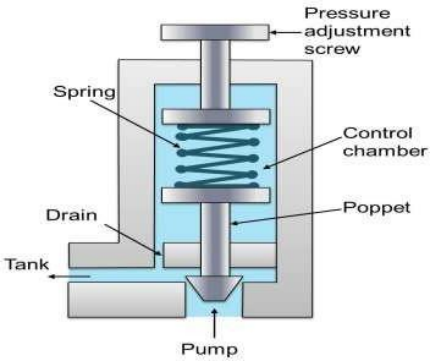

Figure. 5 Pressure Relief Valve

6. Working principle

The pump driven by an electric motor supplies the oil at the required pressure for the hydraulic motor through a filter. The oil at high pressure is pumped to an accumulator from which the oil is given to a direction control valve controlled by a solenoid. The spool position of the direction control valve

Determines the direction of rotation of the hydraulic motor. The direction control valve is a three position spring centered four way valves. In the spring centered position of the four way valve the motor is hydraulically locked.
[7]When the four way valve is actuated into the left envelope, the motor rotates in one direction and when the four way valve is deactivated, motor stops suddenly and becomes locked. When the right envelope of the four way valve is in operation, the motor turns in the opposite direction.

The pressure relief valve provides overload protection for the motor, for example, the motor experiences an excessive torque load. The pressure is indicated by a pressure gauge. The actuated of the circuit loaded in mount on hydraulic motor which impact an beat torque produced in form of axial load in the beat, thus digester door opens in fraction of less than 2 minutes.
Compared to the old way of manual beating it is more efficient and time saving thus the implementation of the new door operating system only occur a bit of cost.

By introducing a timer or switch variant we can make a timed open, instead of manually opened door. The introduction f time will be not accurate because the digester load cannot be predicted and there are many factors including the raw material availability a, leaching process, blowdown and other various function in the IBP section for the time only switched hydraulic circuit is sufficient.

7. Design calculation for hydraulic motor

GPM of Flow Needed for Fluid Motor Speed:

Motor Displacement x Motor RPM ÷ 231

GPM required to drive a 3.75 cubic inch motor at 1500 rpm

Motor Displacement = 3.75 cubic inches per revolution

Motor RPM = 1500

Motor Displacement x Motor RPM ÷ 231 = 3.75 x 1500 ÷ 231 = 24.35 gpm

Fluid Motor Speed from GPM Input:

231 x GPM ÷ Fluid Motor Displacement

GPM = 6

Motor Displacement = 3.75 cubic inches per revolution

231 x GPM ÷ Fluid Motor Displacement = 231 x 6 ÷ 3.75 = 369.6 rpm

Fluid Motor Torque from Pressure and Displacement:

PSI x Motor Displacement ÷ (2 x π)

Pressure = 2,000 psi

Motor Displacement = 2.5 cubic inches per revolution

PSI x Motor Displacement ÷ (2 x π) = 2,000 x 2.5 ÷ 6.28 = 796.19 inch pounds

Fluid Motor Torque from GPM, PSI and RPM:

GPM x PSI x 36.77 ÷ RPM

GPM = 10

PSI = 1,500

RPM = 1200

GPM x PSI x 36.7 ÷ RPM = 10 x 1,500 x 36.7 ÷ 1200 = 458.75 inch pounds second

Fluid and Piping Calculations:

Velocity of Fluid through Pipe

0.3208 x GPM ÷ Internal Area

GPM = 10

Internal Area = .304 (see note below)

0.3208 x GPM ÷ Internal Area = .3208 x 10 ÷ .304 = 10.55 feet per second

The outside diameter of pipe remains the same regardless of the thickness of the pipe. A heavy duty pipe has a thicker wall than a standard duty pipe, so the internal diameter of the heavy duty pipe is smaller than the internal diameter of a Standard duty pipe. The wall thickness and internal diameter of pipes can be found on readily available charts.

Hydraulic steel tubing also maintains the same outside diameter regardless of wall thickness.

Hose sizes indicate the inside diameter of the plumbing. A 1/2″ diameter hose has an internal diameter of 0.50 inches, regardless of the hose pressure rating.

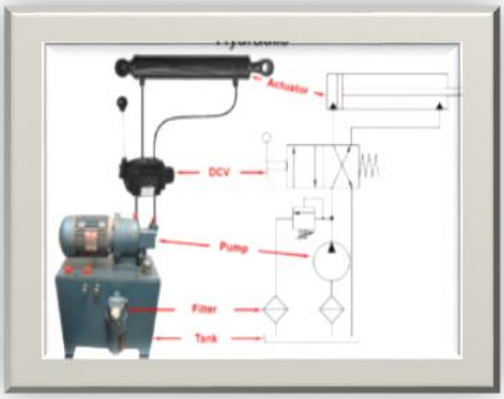

Figure. 6 Overall view of component

Suggested Piping Sizes:

– Pump suction lines should be sized so the fluid velocity is between 2 and 4 feet per second.
– Oil return lines should be sized so the fluid velocity is between 10 and 15 feet per second.
– Medium pressure supply lines should be sized so the fluid velocity is between 15 and 20 feet per second.
– High pressure supply lines should be sized so the fluid velocity is below 30 feet per second.

Digestion is the main process in the manufacture of 1102. 110 digesters in the[6] Ilmenite Beneficiation Plant (IBP) in KMML. The digester equipment having an empty weight of 92.74 Ton. There are eight digesters in IBP which are operating in a sequence. For the feeding and removal of reduced ilmenite the digester door has to be opened and closed. Currently this is done manually.

For the manual operation of the digester door, the manual effort required is very large and also time for this process is also more. The replacement of this manual effort with a hydraulic system helps in avoiding the manual labor as well as saves time

8. CONCLUSIONS

Leaching in digester is the main process in the manufacture of TiO2 in the Ilmenite Beneficiation Plant (IBP) in KMML. The digester equipment having an empty weight of 92.74 Ton. There are eight digesters in IBP which are operating in a sequence. For the feeding and removal of reduced ilmenite the digester door has to be opened and closed. Currently this is done manually.

For the manual operation of the digester door, the manual effort required is very large and also time for this process is also more. The replacement of this manual effort with a hydraulic system helps in avoiding the manual labor as well as saves time.

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