DESIGN AND PROTOTYPING OF A DUST EXTRACTION SYSTEM WITH A SUPPRESSION MECHANISM

(A CASE STUDY OF LIMESTONE DUST ON SMALL SCALE MINES)

BY

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FINAL YEAR PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF MECHANICAL ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AW ARD OF BACHELORS DEGREE IN MECHANICAL ENGINEERING OF KABALE UNIVERSITY.

SUPERVISOR

MR. ATWAKYIRE MOSES

2022

DECLARATION.

I hereby declare that this report is an original copy of my work. It has not been submitted elsewhere to any university for the award of any degree or diploma.

Date: 26/04/2022

KAMBASU BOWEN

APPROVAL.

This is to approve that this report was done by this student under my supervision and is hereby submitted for examination to the department of mechanical engineering.

Supervisor;

Date;

…… ....

………………………

MR. ATWAKYIRE MOSES

ACKNOWLEDGEMENT.

This final year project report has posed both excitement and a challenge to my academic and general life.

However, it is true that for every beautiful piece of work there is always a team of committed and hardworking people that invest most of their time to make it a success.

I therefore wish to extend my sincere appreciation to my supervisor **MR. A TWAKYIRE MOSES** who guided me in coming up with the idea of this topic, building it up, and making it as original as it is right now.

I extend my sincere gratitude to the different people especially my parents MR MUHINDO SAMUEL AND KABUGHO JUSTINE that have nurtured me up to this level and more am indebted to those that spared some time to avail information to me and responded to my questions I therefore thank MR NYEKO IV AN and ENG BWAMBALE JACKSON and the entire staff at HIMA cement factory for the support rendered while working on this very project.

Above all I thank God for the wisdom, courage, and strength that He vested in me during this entire period of studies.

ABSTRACT.

A lot of dust is generated during the course of various mine operations and also other economic activities most especially due to rock fragmentation. The dust is usually beyond the allowable concentrations hence causing negative effects *to* both human life and the environment. Wet suppression has been tried and currently in use but it interferes with the mine operations. This is why I came up with an idea for a dust collection system that cannot interfere with the mining operations and yet affordable.

The dust collection system was designed to avoid the circulation of dust from the point source and the case study was the small scale limestone quarries located in kasese. The designed dust collection system comprises of the hood for capturing the dust from a point source, a cyclone for separating dust using centrifugal force, a hopper for breaking the vortex and an airtight container for collecting the dust. The machine was then tested to examine its efficiency and the efficiency was actually dependent on the length and diameter of the cyclone.

Conclusions and recommendations were drawn from the discussed results got after testing. The designed machine had an efficiency of 78% total dust and replaceable filters will be recommended for further cleaning of the air. The major costs to be incurred by the system are the power costs. This designed system is the best to be used in all areas whether arid or not but only need availability of power.

Contents

TABLE OF FIGURES

CHAPTER ONE

INTRODUCTION

1.I BACKGROUND

Mining, like other activities such as construction, demolition, unpaved road transport, etc. are good sources of dust emission into the atmosphere. In mining, a lot of dust is generated during the course of performing the different activities in the mine. These activities include extraction (it involves drilling, blasting, excavation), mineral processing (crushing, milling screening and concentration) and material handling (transportation of material).

During extraction, mineral processing and transportation, there is rock fragmentation due to impaction, abrasion, cutting etc. and the rock mass is reduced to different size particles ranging from fine to coarse (WHO/SDE/OEH/99.14, n.d.). The generated fine particles circulate into the atmosphere by the aid of moving air and settle slowly after some time under the influence of gravity on the different surfaces in the environment.

This dust contains mineral elements depending mainly on the composition of the rock from which it is generated[1].

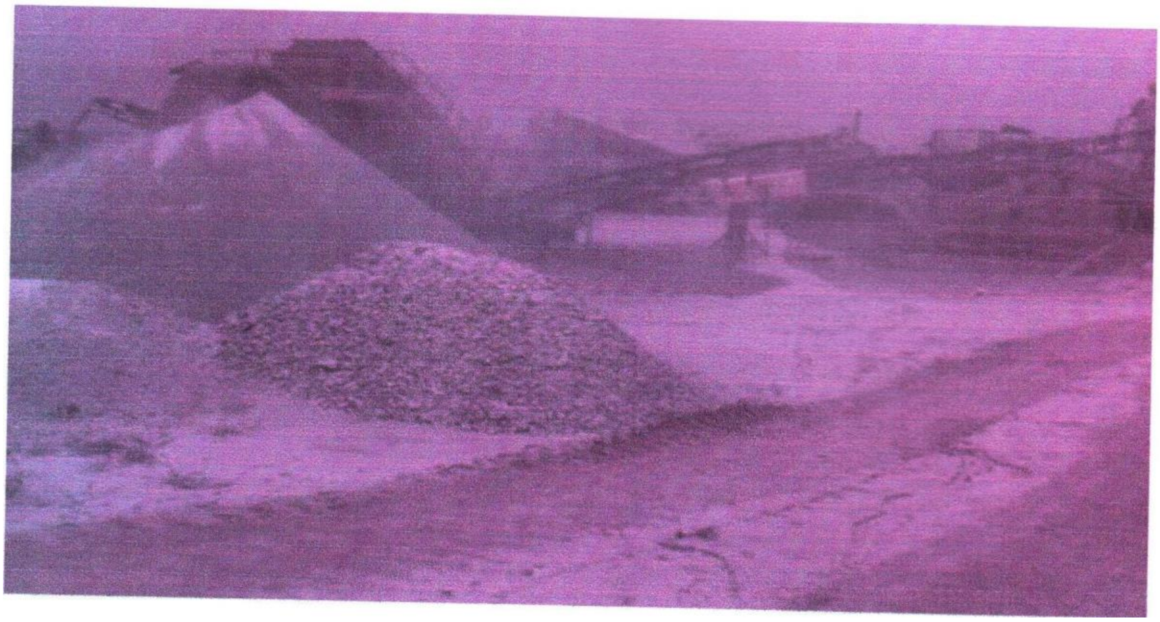


Figure 1 shows one of the quarry sites with dust being generated

Dust released spreads throughout the workplace, and the mineral dust is harmful to the human life and environment depending on their compositions, concentrations and time of exposure[1]. This creates a need for health, safety and environmental management to ensure that mining activities are harmonized with the need to protect human health and to conserve the environment.

In these limestone quarries, a lot oflimestone dust is generated (around 15mg/m^3) which is beyond the allowable concentration of 10mg/m[2] and this is due to the fragmentation of the sedimentary rock composed of calcium carbonates and other elements like iron, magnesium and silica. The workers in the mine are provided with personal protective equipment **(PPE)** to protect them from the effects of dust, but this *is* not enough. At the beginning of 2016, the company introduced wet suppression but it seemingly failed out because it interferes with work and also ends up increasing operational costs.

Therefore there is need to prevent and control the emission of this dust other than allowing it to circulate in the mine. The PPE is inefficient and however some workers neglect putting them on. Hence, to a small extent human health is protected but the environment is not considered as well.

1.2 PROBLEM STATEMENT

In the small scale limestone quarries of Molem and Hima, limestone dust is generated which is harmful to the environment and human beings depending on the concentration, composition and exposure time to the dust, thus causing various effects like poor vision, dirtying of the surfaces and equipment damage and wear. These effects increase expenditures on cleaning and maintenance costs for equipment hence increasing operational costs. Therefore there is need to control dust circulation in these srnaJl scale mines.

1.3 OBJECTIVES

1.3.1 MAIN OBJECTIVE

To design a dust extraction system with a suppression mechanism.

1.3.2 SPECIFIC OBJECTIVES

1. To determine and conceptualize design parameters of various components of the dust extraction system.
2. To develop and prototype the appropriate machine model of the sized components.

3.To evaluate performance of the designed and prototyped dust extraction system. **1.4**

JUSTIFICATION

There is circulation of limestone dust in the atmosphere of 15.0mg/m' beyond the allowable concentration of 10.0mg/m (Environmental audit report, July 2020) of total airborne dust thus creating an unhealthy and unsafe working environment. Therefore, there is need for implementing the designed dust extraction system to prevent dust circulation. A dust free environment is good for human health.

1.5 SIGNIFICANCE

At the end of this project, the following would be realized;

1. Reduction on dust-related human respiratory and skin problems like bronchitis, irritating eyes and more so allergies.
2. Reduction on equipment wear and damage most especially due to mechanical abrasion.
3. Reduction in cleaning costs.

1.6 SCOPE

This project majorly focuses on the design of a dust collection system with a suppression mechanism and the case study is the limestone dust generated on small scale limestone mines of Molem and Hima used by Hima cement a member of Lafarge holeim.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

This section presents the description of dust, how dust is generated, types of dust, effects of dust and how dust can be well controlled and minimized.

2.1 DEFINITION, DESCRIPTION AND CONCEPTS

2.1.1 Dust

Dust are small dry solid particles that are generated at a given point and they circulate into the air by diffusion and remain suspended in the atmosphere for some time after which they slowly settle out on surfaces under the influence of gravity. Dust particles are normally in the size range from about I to I 00 m in diameter, which may be or else become airborne, depending on their origin, physical characteristics and ambient conditions.

2.1.2 Major composition of limestone dust

- Calcium carbonate
- Magnesium carbonate
- Silica-crystalline quartz

Table lPhysical and chemical properties of limestone dust[3]

Properties	**Details**
State	Solid
Odour	Odourless
Appearance	Grey powder
pH	9.4 in saturated water solution at 25c
Solubility	Slightly soluble in water
Specific gravity	2.7
Reactivity	Reacts with acids to form calcium salts while generating heat
Decomposition temperature	95°%e

2.2 HOW DUST IS GENERA TED

In mining, dust is emitted when ore is broken by impact, abrasion, cutting during *mine* operations like crushing, grinding, blasting, drilling, material haulage etc. And disturbance on settled fine particles; through release of previously generated dust during operations such as loading, dumping and transferring and also through recirculation of previously generated dust by wind or by movement of workers and machinery. The amount of dust emitted by these activities depends on the physical characteristics of the material and the way in which the material is handled.

2.3 TYPES OF DUST

From an occupation heaJth point of view, dust is classified by size into three primary categories that is respirable, inhalable and total dust.

Respirable dust: refers to those dust particles that are small enough to penetrate the nose and the upper respiratory system and deep into the lungs. These dust particles which penetrate deep into the respiratory system are generally beyond the body's natural clearance mechanisms of cilia and mucus and are more likely to be retrained. Respirable dust cannot be seen with the eye. More so, if a dust cloud is visible, it is likely that a portion of the airborne dust will be in the respirable size range. It also has an aerodynamic diameter below 10m[4].

- **lnhalable dust** is that size fraction of dust, which enters the body, but is trapped in the nose, throat, and upper respiratory tract The median aerodynamic diameter of this dust is nearly about 1 Oμm.
- **Total dust** includes all airborne particles, regardless of their size and composition

2.4. EFFECTS O.F DUST

The generation and escape of dust into the mine atmosphere is undesirable, although unavoidable in some mining operations but can be controlled below allowable concentrations. Excessive dust (beyond allowable concentration) can cause health, environment and industrial problems. Effects include(4]:

- Health problems e.g. Respiratory diseases like influenza, and also irritation to the skin and eyes.
- Poor vision due to formation of dust cloud and this may lead to accidents
- Unpleasant odours
- Equipment wear especially for components such as bearings and pulleys on which fine dust can cause a "grinding" effect and increase wear or abrasion rate hence increasing maintenance costs
- Dirties surfaces hence increasing the cleaning and maintenance costs for homes.

Note: The harmfulness of the dust depends on the following factor. dust composition, dust concentration, particle size and shape and exposure time.

2.5 DUST *CONTROL*

Dust control is basically defined as a science of reducing harmful dust emissions by applying some engineering principles which are scientifically proven. Properly designed, maintained and operated dust control systems reduce dust emissions and thus workers' exposure to harmful dusts.

2.5.1 Steps in controlling dust

- **Prevention:** this is the first step and it avoids dust from being generated (formed). It is the best way to control dust though it is hard to be achieved.
- **Control systems:** this is after prevention measures have been taken/cannot be taken but when there is still dust being released in the atmosphere. Dust circulation is then avoided by suppressing, capture and collection of the dust using various suitable techniques.
- **Dilution-isolation:** this generally reduces dust concentration in the area by diluting the contaminated air with the uncontaminated air fresh air. It is not satisfactory for health

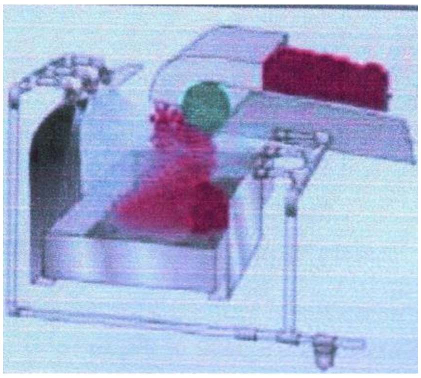
hazards control or dust coJJecting systems; however, it may be applied in circumstances where the operation or process prohibits other dust control measures.

2.6 EXISTING DUST CONTROL TECHNIQUES USED ON VARIOUS QUARRIES. 2.6.1

Wet dust suppression

This technique involves the use of wet spray systems. In essence, as fines are wetted each dust particles' weight increases thus decreasing its ability to become airborne. As groups of particles become heavier, it becomes difficult for the surrounding air to carry them away. In most cases, the wet spray commonly used is a water spray system. There are two methods mainly used which include air borne dust prevention achieved by direct spraying of the ore to prevent dust from becoming airborne and airborne dust suppression which involves knocking down already airborne dust by spraying the dust cloud and causing the particles to collide, agglomerate and fallout from the air[5].

2.



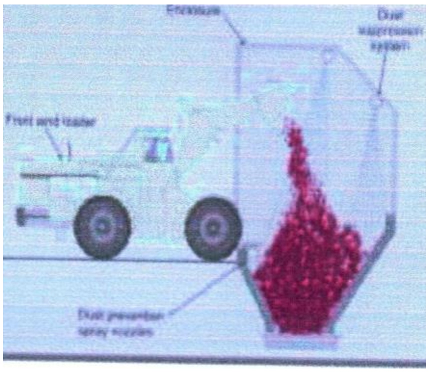


Figure 2 wet suppression system

This also includes wet drilling method where water is injected along with air to flush cuttings out of the hole as shown in the figure.

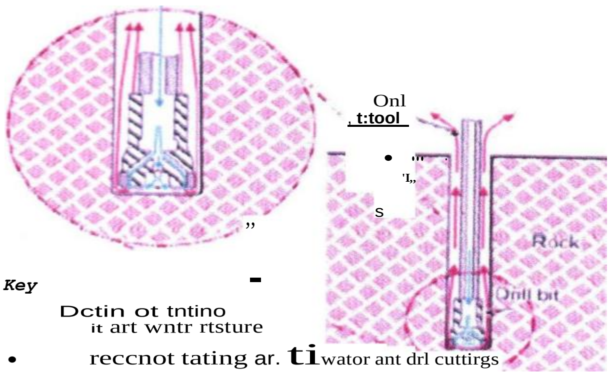


Figure 3 wet drilling method

To provide for wet drilling, a water tank mounted on the drill is used to pump water into the bailing air and the water droplets trap dust particles as they migrate up the annular space of the drilled hole (the annulus is the open area of the drill hole between the drill steel and the wall of the drill hole) thus controlling the dust as the air bails out the cuttings.

It also involves controlling dust on haul roads with the help of suppressants and water being the most commonly used. Its application is achieved using a water truck which sprays water onto the roads.

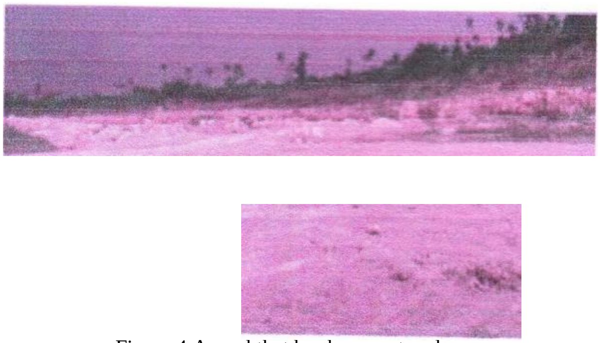


Figure 4 A road that has been watered

Advantages of wet dust suppression

- Enclosure tightness is not essential.
- It is simple to design and operate.
- Least expensive method of dust control.
- When good mixing of water and material is done dust generation can be effectively reduced.

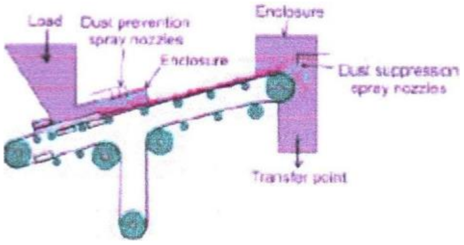
Disadvantages of wet dust suppression

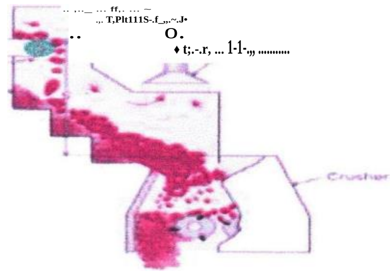
- It cannot be used with dust, which reacts with water.
- It requires large quantities of water thus water should be readily available.
- Increases the weight of the material.
- Surface wetting due to excess water used thus causing muddy and slippery conditions

2.6.2. Dry control techniques

This is achieved by using exhaust ventilation to create a negative air pressure inside the controlled space relative to outside of the controlled space. Most operations will use a combination of both of these methods in the overall dust control plan[5].

4.





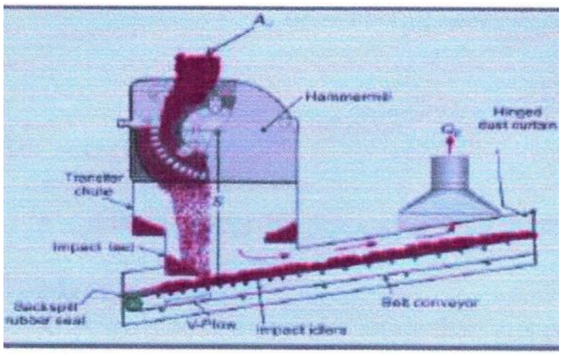
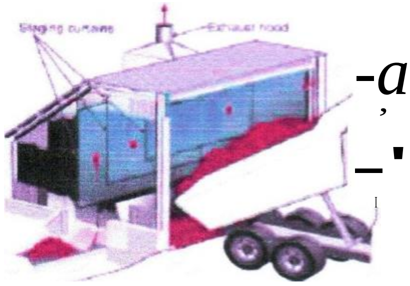


Figure S Dry dust control technique



This control method also involves dry drilling which is accomplished without use of water for dust control by using a dust collection system on the drill as shown in the figure below.

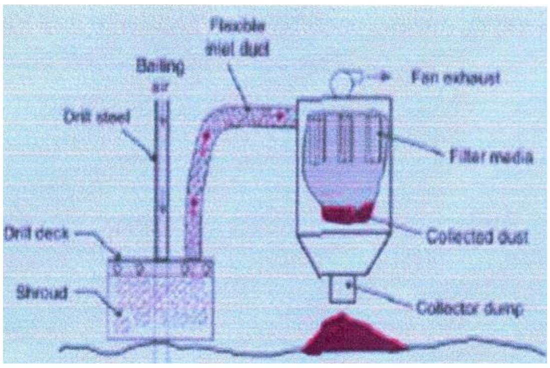


Figure 6 A basic dry dust collection system on the drill

5.

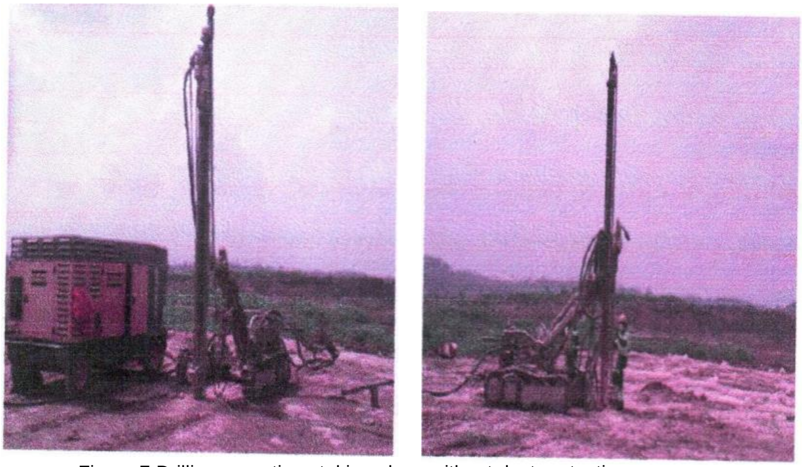


Figure 7 Drilling operations taking place without dust protection

Advantages

- It is very effective.
- It is necessary for products which do not require addition of water.

Disadvantages

- Costly to install and operate than wet control methods.
- It works best in enclosed areas like tunnels unlike open areas.

2. 7 RESEARCH QUESTIONS

I. What are the existing dust collection machines and their operation mechanisms?
2. How can the Dust collection system be designed?
3. What are the suitable materials and sizes of components of the system?
4. What are the economic implications of the system?

6.

CHAPTER THREE

3.1 METHODOLOGY

3.1.1 INTRODUCTION

The methodology explains the methods that were used to fulfill the objectives of the study. This also shows a design procedure that targeted towards the achievement of the project objectives.

3.1.2 RESEARCH DESIGN

Research design is the one which describes the nature and pattern, which the research followed for example whether longitudinal or cross-sectional, qualitative or quantitative, descriptive, explanatory or experimental, case based or representative.

3.1.3 SOURCES OF DATA

A combination of primary and secondary was collected from the sources.

Primary data

This was collected from individuals dealing in spare parts of dust extraction systems and machines and machine tool shops. Some other data was obtained from the limestone quarries. **Secondary data**

This was collected through a review of literature on dust extraction technologies. The sources for this secondary data were the internet, written information from library about the subject matter, previous studies done in areas of study, publication documents from the dust extractor industries. This reviewing literature provided supportive evidences to fulfill the objectives of the study so as to address the problem stated by the study.

A). To determine and conceptualize design parameters of various components of dust collection system.

Internet

The internet will be used to read different literature about the dust collection system requirements of the would be design.

Relevant data on material selection will be obtained.

Engineering design methodology

This technique will be used to determine and calculate using suitable formula the required size of the shaft, frame, motor, fan etc.

All this will be used in the computation analysis of system parameters. **3.2**

DESIGN EQUATIONS.

3.2.1 Determination of power requirements of the system.

The researcher obtained the power required by the system to suck the dust from the point source during operation in other words the power to run the fan *As* started in an international journal of emerging trends in Engineering and Development ISSN 2249-6140 Issue 2, Vol.4 (May 2012).

Power requirement by the machine p *.P*

TJ

Qx4500.7

5

Design Horse Power, H *P*

HP = Rated power x Service factor

3.2.2 Design of the fan

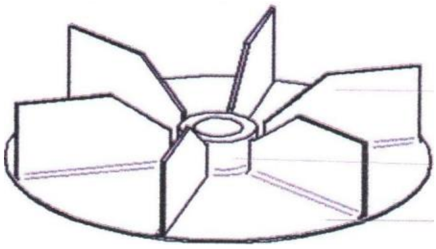


Figure 8 fan design

The fan will be located at the top of the cyclone. It is a mechanical fan with impelJers attached to the shaft, all in an in volutes casing. The shaft was attached to the motor directly.

The following were considered when designing a fan;

- Operating requirements and conditions like air flow rate and pressure
- Operating life of the fan and the material to be handled.

Construction of the fan was a combination of *6* fins of metal plate, the bush and the round metal plate. Welding was used to join the constituent parts.

a) The fins

Figure 9 the fin of the fan

The fin was made out of mild steel plate of 2mm thickness cut to the shape above. With arc welding, fillet welds were used to join the fins to the round plate and the bush.

b) Bush

It was made by cutting a piece of 30 mm long off a long shaft which is then machined and then a hole of 24mm is bored through. The bush is then positioned on the round plate by arc welding of fillet welds. There are internal threads made on the shaft of 10mm so that a bolt ofMl0 can be used to fasten the fan onto the driving shaft.

c) fan shaft

Fan shaft of35mm is cut to a length of 160mm and then reduced to various sizes depending on the various components to be fitted on to it. At the extreme end, threads are made of 12mm so that the Ml2 nut can be fitted on.

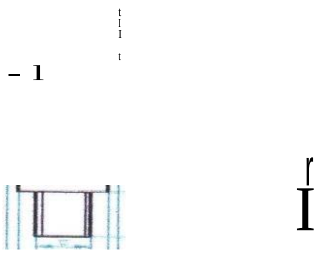


Figure 10 shaft design

Force exerted by the motor shaft by the fan.

The total force exerted on the shaft by the fan was determined from the total weight of all the different components of the fan like the blades and the bushes. The fan to be used has six blades. The weights w determined from the equations below;

$W = nmg$ Butm =

pv

Thus $W = npvg$

=6x 7850 XV

3.2.3 Design of the cyclone

The cyclone has a sma1J diameter and a long cylindrical body joined to a long cone to maximize its separation efficiency.

A small diameter increases the centrifugal force $\frac{mv^2}{r}$ needed to overcome the drag force

Where m= mass of the particle

V= velocity of the particle

r = radius of the cyclone at a point

A long cylindrical body avoids the abrupt transition from the cylindrical body to the cone which would cause body wear. A Jong cone enables smooth transfer of particles to the hopper and also increases retention time. In the cone, the rotational radius of the dust-laden air stream is reduced thus smaller particles also separated. A long cyclone thus increasing the residence time $\frac{Q_{in}}{V_e}$

WhereQ~ = flow rate at the inlet

V_e= volume of the cyclone

But, Volume of the cylindrical body= $\pi r^2 h$

Volume of the cone $\frac{(D?-a?)h}{12}$

3.2.4 Design of the frame.

The frame has four legs which are 85 to the ground, this enable it to support the entire weight of the system. The total weight carried by the stand includes the weight of; cyclone, hopper, hood, ducts, involute casing, fan and the motor.

The compressive stress on each machine leg is

=1134.486N

3.2.5 Bolts

The joining of the parts was done using connections that can be disassembled without destruction methods. The joints used will be strong enough to resist both external tensile loads and shear loads or a combination. The bolts used will be in various sizes these included M6, MIO, MI2and MI6.

- M6 used to fasten the fan housing to the cover.
- MIO used to fasten the motor frame onto the cover.
- Ml2 used to fasten the motor frame onto the mainframe.

The following stresses in the screwed fastening due to static loading are important from the subject point of view;

- Internal stresses due to screwing up forces
- Stresses due external forces and
- Stress due to combination of stresses at (1) and (2)
- Internal stress due screwing up forces

The following stresses are induced in a bolt, screw or stud when it is screwed up tightly. **a)**

Tensile stress due to stretching of bolt

Since none of the above mentioned stresses are accurately determined, therefore bolts are designed on the basis of direct tensile stresses with a large factor of safety in order to account for the indeterminate stresses. The initial tension in a bolt based on experiment may be found by the relation P = 2840dN

Where;

P = initial tension in a bolt and

D = Nominal diameter of bolt in mm

The above relation is used for making a joint fluid tight like steam engine cylinder cover joints etc. when the joint is not required as tight as fluid- tight joint, then the initial tension in a bolt may be reduced to half of the above valve. In such cases P = 1420 N

The small diameter bolts may fail during tightening, therefore bolts of smaller diameter (less than M 16 or M 18) are not permitted in making fluid tight joints. If the bolts is not intially stressed, then the maximum safe axial load may be applied to it and is given by

P = Permissible stress x cross- sectional area at the bottom of the thread (stress area) The

stress area may be obtained using the relation

stress area = 4 P2

Where;

d = pitch diameter

de = minor diameter

b) Torsional shear stress caused by the frictional resistance of the threads during its tightening.

The torsional shear stress caused by the frictional resistance of the threads during its tightening may be obtained by using the torsional equation known as;

T t J

r

$$7\frac{16T}{a.}$$

τ = Torsional shear stress

T = Torque applied

c) Shear stress across the threads

The average thread shearing stress for the screw τs is obtained by using the relation:

$$\tau_o = \frac{p}{rd x b x n}$$

Where b = width of the thread section at root.

$$\tau_n = \frac{P}{rrd \times b \times n}$$

Where d = major diameter

d) Compression or crushing stress on threads.

The compression or crushing stress between the threads (o)may be obtained by using the relation:

p

Op@?-@j

Where n = number of threads in engagement.

Bending stress if the surface under the head or nut are not perfectly to the bolt axis. When the outside surface of the parts to be connected are not parallel to each other, then the bolt will be subjected to bending action. the bending stress (ob) induced in the shank of the bolt is given by

$$\sigma_b = \frac{X.E}{2l}$$

Where X = Difference in height between the extreme corners of the nut or head,

L = length of the shank of the bolt

E= Youngs modulus for the material of the bolt

B). To develop and prototype the appropriate machine model of the sized components and its prototype.

Internet search.

This will be used to get information on the existing designs presented in international journals. More so relevant design data will be read and used to sketch out the proposed design. **Software design technique.**

This *will* mainly make use of the solid works and AutoCAD software to transform proposed design sketches into real engineering drawings.

More so with this very technique, all parts can be assembled together as well as labelled.

Fabrication of the designed component will be done following the design parameters. **The Assembled drawing.**

The cylindrical body was joined to the cone body by folding thus forming a cyclone. The cyclone was joined to the stand by welding. The vortex breaking hopper was joined to the cone by welding and also the discharge duct was welded to the hopper. The involute inlet was welded to the cyclone while the fan casing was bolted onto the involute inlet. The motor stand was also attached to the fan casing by welding.

7.

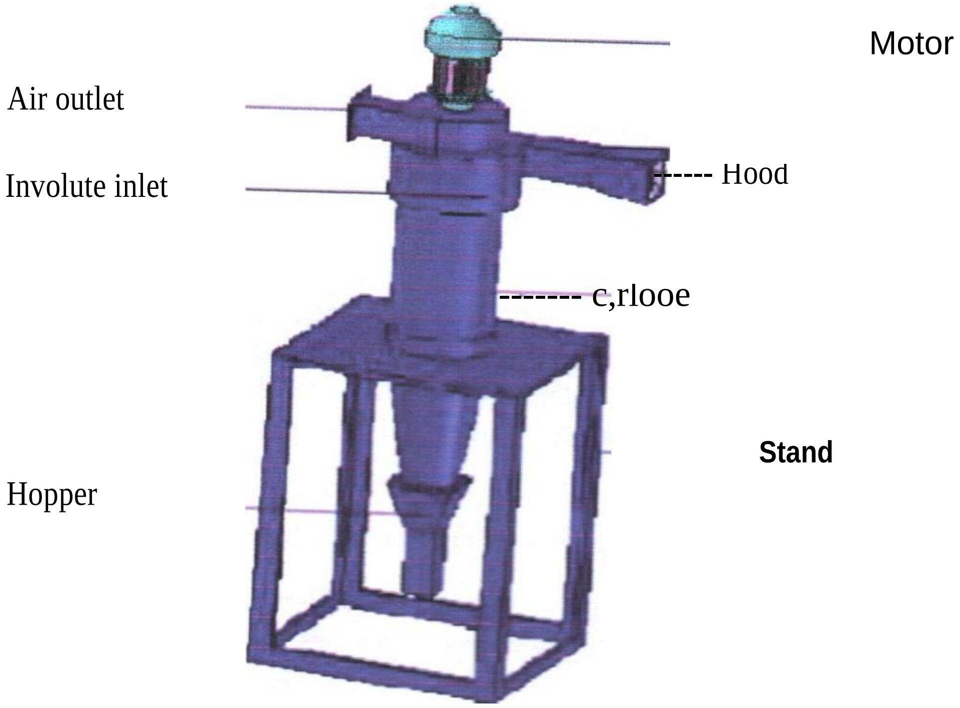


Figure 11 the assembled solid **works drawing**

C). To evaluate the performance of the designed and prototyped dust collection system. Data analysis.

This technique will be used to calculate the efficiency of the designed machine and its performance. Efficiency is expected to be around 78%.

More so with the data analysis we shall be able to determine the major operational costs incurred of the proposed design.

$$\text{Collection efficiency} = \frac{\text{inlet loading}(W1) - \text{outlet loading}(W2)}{\text{inlet loading}(W1)} * 100$$

PV=Y;_, "2 ≥0wnere; B =Dust control incremental benefits. - 1+Rt

C =Dust control incremental cost.

t = project life span

R= Discounting factor.

CHAPTER FOUR.

DATA PRESENTATION, DISCUSSION AND ANALYSIS. 4.0

INTRODUCTION

This chapter contains the findings and the results of the research that was carried out. It gives detailed description and discussion of the data acquired during the research in line with the specific objectives and therefore conclusions in the next chapter were drawn accordingly.

4.1 Existing dust extraction method in the small scale mines.

This technique involves the use of wet spray systems. In essence, as fines are wetted each dust particle weight increases thus decreasing the ability to become airborne and more so dirtying of the surface. As groups of particles become heavier it becomes difficult for the surrounding air to carry them away.

In most cases the wet spray commonly used is a water spray system. *4.2*

Mechanical properties of the material.

The mechanical properties that were considered are; strength of a material, ductility, toughness and machinability of the material.

The material ought to be strong and tough enough to withstand forces but also easy to bend and to be machined.

4.2.1 Availability and cost of Material.

The materials which were readily available on market, efficient and relatively cheaper in terms of cost was used in the design of the system such that the cost of the completed system is affordable to the user.

Selection of material.

Component	Possible material	Selection criteria	Material selected
Hood	Mild steel, galvanized iron	Strength, wear resistance, availability, cost	Mild steel
Involute inlet	Mild steel galvanized iron	Cost, strength, wear resistance, availability,	Mild steel
Fan	Mild steel, galvanized iron	Strength, wear resistance, **availability,** cost	Mild steel
Main frame	Aluminium, wood, mild steel	Cost, strength, wear resistance, availability,	Mild steel
Ducts	Mild steel, rubber, plastic	Cost, strength, wear resistance, availability,	Mild steel
Cyclone body	Mild steel, galvanized iron	Strength, bend ability, cost	Mild steel
Hopper	Mild steel,	Cost, strength, wear resistance, availability,	Mild steel
Dust container	Plastic, sack, metal	Airtight	metal

4.2.2 Product design specifications for the dust extraction system.

Performance: The system has support legs at an angle 0f 85 degrees to the ground for stability on unlevelled ground.

8.

Maintenance: The system is easy to maintain using simple maintenance methods. **Cost:**

Uganda shillings.

Market: Dust extraction process.

Ergonomics: The system is easy to use since it has an on and off power button, it is portable therefore it can be transferred from one point to another.

Safety: The machine is stable on ground, weJJ insulated to avoid electric shocks, and has round edges to avoid bruises that are caused by sharp edges.

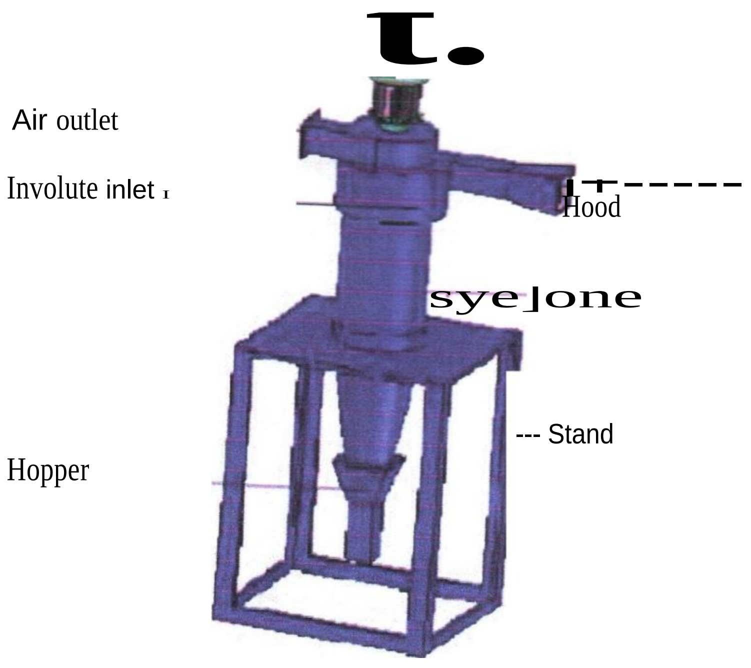
Customer: Targeting industries and factories.

Capacity: 44kg of dust and preform off cuts.

4.3 The designed system.

4.3.1 Designed system description.

The dust extraction system consists of the following basic parts hood, ductwork, involute inlet, cyclone, hopper, mainframe, fan and the motor. The other parts of the machine include the dust collecting bin and the filter cloth.



4.3.2 Mode of operation of the design.

The dust laden air enters the collector tangentially at the top and creates a vortex pattern flowing helically downward. Centrifugal force causes the heavier dust particles to move outward towards the cyclone wall.

Friction and gravity then force the dust to fall in the receiver. The cleaned up air spirals up in the inner vortex at the centre of the cyclone and exits at the top of the unit.

4.3.3 Advantages of the system.

- low maintenance costs
- No movable parts
- Does not interfere with the operation
- It is easier to set up and operate since it is portable
- It works in all environments (both enclosed and open areas)
- It is user friendly

4.4 Testing for the efficiency of the system.

The assembled system was powered and about 4 samples of limestone dust were weighed (WI) and distorted to put the dust in motion near the hood of the dust collection system.

The weight (W2) of the dust collected after sometime was determined. The efficiency of the assembled system was determined from the equation below. Procedure was repeated many times and the average weights of the inlet and outlet dust were used to calculate the efficiency.

$$\text{Collection efficiency} = \frac{\textit{inlet loading(W1) - outlet loading}\ \text{(W2)}}{\textit{inlet loading}\ \text{(W1)}} \cdot 100$$

Test of collection efficiency results.

Sample number	Inlet loading (g)	Collected dust(g)	Outlet loading(g)
1	500	380	120
2	800	690	110
3	600	460	140
4	500	360	140

The designed system was tested and it was found that it has an efficiency of 78%. The efficiency was limited by the length of the cyclone, the longer I would make it the more it would get more efficient though the funds limited me.

Therefore when the length of the cyclone is increased the residence time of the particle is increased thus more particles separated hence improving its efficiency.

Other parameters.

Mass flow rate= 0.93 m^3/s

Residence time= 90s

Number of effective turns= 32.1 **4.5**

Cost evaluation of the system.

After testing the performance of the system, cost evaluation of the system was carried out using cost benefit analysis.

It was based on the equation below;

pv7 B-0,9
.l.rt=O (l+R)t

Where; B= dust control incremental benefits

C= Dust control incremental cost

R= Discounting factor

t = project life span

4.5.1 Economic Analysis.

The system is economically friendly to the user, only power cost to run the machine will be the most incurred. Since the system has no moving parts, maintenance costs are very minimal and no operational cost because there is no operator needed.

The system benefits the user by minimizing expenditures on correcting the effects caused by dust e.g. cleaning costs, maintenance costs of the equipments etc.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS. 5.1

CONCLUSION.

The objective of this project was to design a small scale dust extraction system which is user friendly, effective and also economical. The analysis of different elements was carried out to determine its dimensions.

The machine was well designed with few components and hence easy to operate and maintain. **5.2**

RECOMMENDATION.

- Force analysis on the hopper should be further analysed.
- Research should be carried out on the cost of producing each element and its material availability.
- Further analysis should be carried out for- the support frames.

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APPENDICES

Determination of power

Power required by the system p = P n

Where;

Q-Flow rate of grain chaff in m^3/s

P-- Static pressures for air at standard temperature and pressure (STP)

- Efficiency of the fan type.= 75% (BEE India, 2004) But Q =

Vx (I0X^2 +A) (Dallavale, 2010)

Where V- Velocity of flow of limestone dust =17.8m/s(Cecala, 2003)

A- Cross sectional area of the hood face opening (m) (A=Length x Width)

X= distance from the hood to the point source (m) (considered is 0.035m)

Design Horse Power, H P

HP = Rated power x Service factor

FORCE EXERTED ON THE FAN

$$W = nmg$$

But m = pv

Thus $W = npvg$

Where; W - Weight of the component *n*-

Number of blades

g - Gravitational force

m- Mass of the blade, **kg**

v - Volume of a blade, m^3

p - Density of the material used, kg/m'

But bulk density of mild steel is 7850Kg/m^3•

VOLUME OF HOPPER AND HOOD

Volume = -a%!%h
3 3

Where; a= dimension of the big square base (m).

b = dimension of the small square (m).

H = Height of the pyramid before it was truncated (m).

b = height of the removed part (m).

COMPRESSIVE STRESS ON MACHINE LEG

The compressive stress on each machine leg is given by De= !.... *nA*

Where F= Force on the machine leg

A= cross-section area of the frame leg

n = number of frame legs

De = compressive stress