DEVELOPMENT OF AN EROSION TESTING MACHINE

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology

In

Mechanical Engineering

By

Samarendra Das

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Gopal Krishna Nanda

Department of Mechanical Engineering

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Under the guidance of

Prof. S.K.Acharya

Department of Mechanical Engineering

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CERTIFICATE

This is to certify that the thesis entitled, **“Development of an Erosion Testing Machine”** submitted by **Sri Samarendra Das** and **Sri Gopal Krishna Nanda** in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Mechanical Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by them under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

Prof. S.K.Acharya

Date: Dept. of Mechanical Engineering

National Institute of Technology

Rourkela

National Institute of Technology

Rourkela

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Date: - **Samarendra Das** **Gopal Krishna Nanda**

Place:-

CONTENTS

ABSTRACT

An erosion tester is normally used to study the relative erosion behavior of different materials at moderate solid concentrations. Uniform distribution of solids and turbulence inside the container are generally the problems with the erosion tester and thus the data generated have limited application for quantitative analysis.

In the present work, an existing mechanical stirrer has been converted into a slurry erosion tester by designing and fabricating a specimen holding arrangement for cylindrical and flat specimen by taking suitable dimensions according to experimental needs. Using this slurry erosion tester experiments can be carried out for investigating the wear characteristics of various materials which are subjected to slurry erosion. The machine has been tested by taking slurry of mud in a stainless steel container to find the rate of mass loss of an aluminium sample.

This machine can be used for carrying out experiments on various samples of different materials which are subjected to slurry erosion by taking different types of slurries to find out the wear characteristics of the material by measuring the rate of mass loss with respect to various parameters like Slurry concentration, Speed of rotation, distance traversed and time.

LIST OF FIGURES

Chapter 1

INTRODUCTION

INTRODUCTION

1.1THE PHENOMENON OF WEAR

1.1.1 DEFINATION:

Wear is defined as the damage to a solid surface, generally involving progressive loss of material, due to relative motion between that surface and a contacting substance or sub-stances.

1.1.2 TYPES OF WEAR:

Abrasive wear: It is the type of wear caused due to hard particles or hard protuberances forced against and moving along a solid surface.

Examples: Occurs in the gears used in Mining operations,Occurs during Abrasive jet cutting

Adhesive wear: It is the type of wear caused due to localized bonding between contacting solid surfaces leading to material transfer between the two surfaces or loss from either surface.

Examples: Occurs between two matting gears,Occurs between rail and wheel

Erosive Wear: It is the progressive loss of original material from a solid surface due to mechanical interaction between that surface and a fluid

Examples: Occurs in Sandblast equipment,Occurs in the Pipe elbow Oil drilling, pumping,Occurs in the agricultural equipments

Surface fatigue wear: It is the wear of a solid surface caused by fracture arising from material fatigue.

Examples:Occurs when a material is subjected to continuously fluctuating load, Occurs due to vibration between the matting parts

Corrosive wear: It is the wear which occurs due to the chemical or electrochemical reaction with the environment.

1.2 EROSION

1.2.1 DEFINATION

Erosion, in tribology, is the progressive loss of original material from a solid surface due to mechanical interaction between that surface and a fluid, a multi component fluid, or impinging liquid or solid particles,

Erosion rate is the determination of the rate of loss of material (erosion) with exposure duration.

1.2.2 TYPES OF EROSION

A. Solid Particle Impingement

Solid Particle Impingement is a form of erosion produced by a continuing succession of impacts from solid particles on a surface. The impacting particles are smaller than the solid subjected to the erosion, and if all the impacts are superimposed on the same spot, the term repeated impact is used.

Area of occurrence: It occurs in Sandblast equipment.

B. Fluid Impingement

Fluid Impingement is a form of erosion caused by a continuing succession of impact from a jet of fluid on a surface.

Area of occurrence: It occurs in Pipe elbow, rainfall on an aircraft

C. Cavitation

Cavitation erosion is progressive loss of material from a solid due to the action of bubbles in a liquid collapsing nears the solid surface. When bubbles collapse in a liquid, the liquid surrounding the bubble rushes in to fill the void. This action can create tiny liquid jets that can cause material removal.

Area of occurrence: It occurs in Pumps, mixing impellers, ultrasonic devic

D. Slurry Erosion

Slurry erosion is progressive loss of material from a solid surface by the action of a mixture of solid particles in a liquid (slurry) in motion with respect to the solid surface. If the solid surface is capable of corroding in the fluid portion of the slurry, the slurry erosion will contain a corrosive component.

Area of occurrence: It occurs in Oil drilling, pumping, mineral beneficiation.

A number of engineering components undergo wear related degradation during operation, the exposure to wear prone condition vary with the operating conditions. Depending upon the nature of exposure, a suitable material should be selected for its fabrication. It is not always feasible to carry out the field level studies before proposing the quality of material required for a components fabrication and the results of laboratory scale studies assume significance and have to be considered. There is a wide variety of laboratory level tribologically tests equipments available; however proper selection has to be made from amongst the laboratory tests available based on the nature of the components under actual working conditions.

The aim of the project is to develop and modify the slurry erosion tester for testing the rate of erosion wear and slurry erosion properties under varying experimental conditions like Slurry concentration, Speed of rotation, Distance traversed and Time, taking different samples of some commonly used materials.

Chapter 2

LITERATURE REVIEW

2.1 SLURRY EROSION

2.1.1 DEFINATION:

Slurry is the suspension of solid material in liquid. Slurries are transported and processed by a wide range of equipment in the mining, power generation and dredging industries. Centrifugal pumps and cyclones are used extensively in these applications. A major consideration of equipment operators in these industries is the wear life of equipment.

The predominant type of wear in slurry handling equipment is erosion. Studies into the factors contributing to erosive wear have focused on particle size, shape, impingement angle, impact velocities and material characteristics.

2.1.2 AREAS WHERE SLURRY EROSION TAKES PLACE.

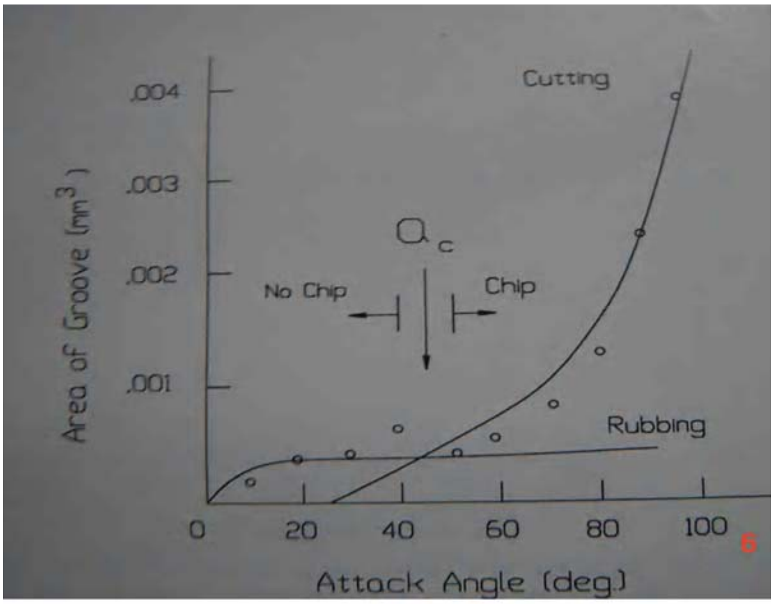
1. Oil drilling, pumping, mineral beneficiation
2. Agriculture equipments
3. mining industries
4. During milling and transportation of ores through pipes and pumps
5. Abrasive jet cutting

2.2 FACTORS AFFECTING EROSION WEAR

1. Attack angle
2. Force of impingement
3. Distance of fall

Attack Angle

It has been demonstrated that the angle of attack between leading edge of the particle and the wearing surface determines whether or not cutting will take place. below a critical value, deformation takes place.



(Fig 2.1 the effect of attack angle on chip formation in abrasion)

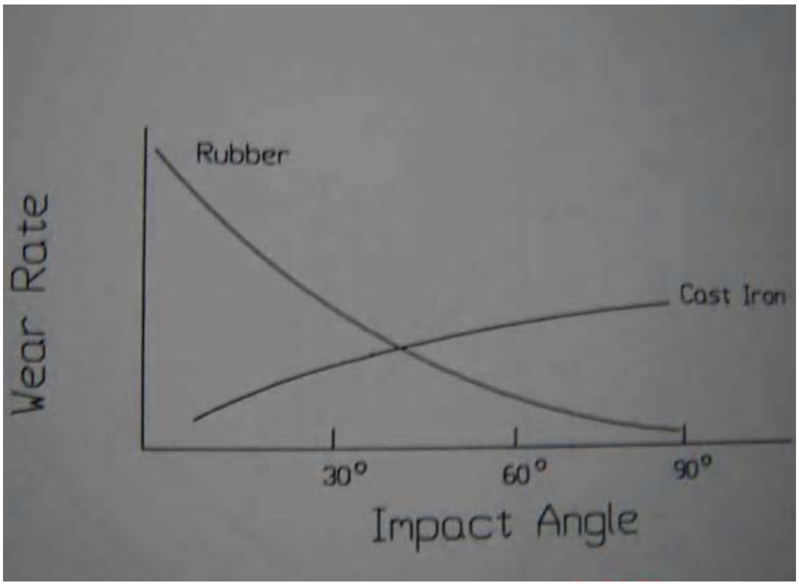
It has been demonstrated that the angle of attack in the above diagram, between the leading edge of the particle and the wearing surface determines whether or not cutting will take place. Below a critical value, deformation takes place. The critical angle is primarily determined by the co-efficient of friction between the particle and the wearing surface, as shown by the above relation.

$$\tan(90-Ac)=(1-\mu^2)/2\mu$$

Ac: Critical angle for cutting to occur

μ: Coefficient of friction.

The critical angle is usually in the range of 30 to 60 degree. The SEM micrographs and profilometer traces illustrating these two actions is shown in the figure; in addition a transition or mixed mode is illustrated. The SEM micrographs as well as profilometer traces show the formation of lip or ridge along the groove for both the ploughing and the mixed or the wedge forming mode. The ridges are the result of plastic flow. The potential for debris or chip formation can be seen for the cutting and the wedge formation mode.



(Fig 2.2 Effect on Impact angle on Wear rate of different materials)

From the above diagram it should be noted that the desired angle should be on the right side of the critical angle i.e. for ductile materials it should be greater than the critical angle and for brittle material it should be lower than the critical angle. The differences are observed due to the physical properties. As ductile material has greater resistance to shear as compared to a brittle material. Similarly a lot of other factors like metallurgy, crystal structure, and other physical properties come into play.

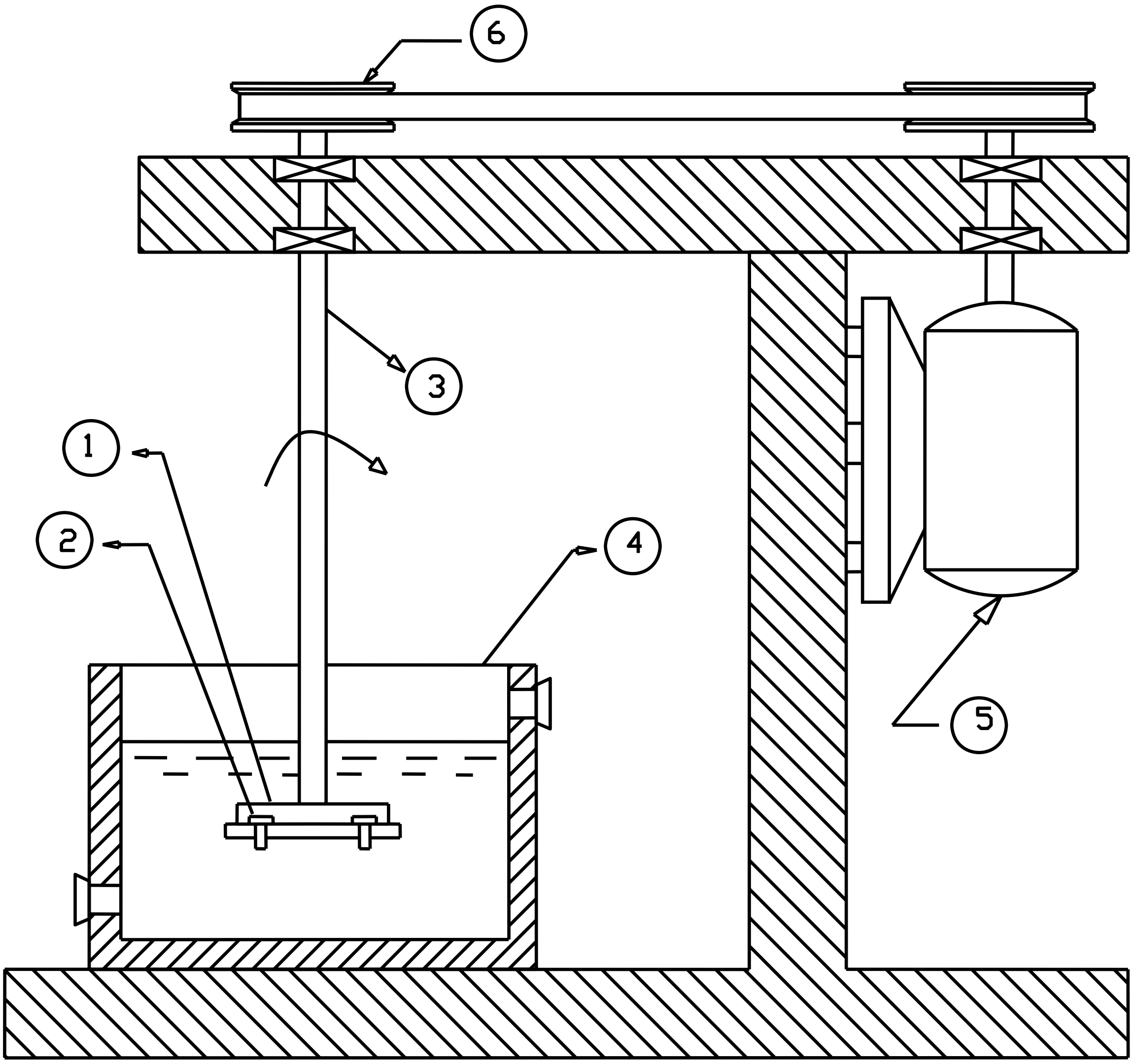
Chapter 3

DESIGN AND FABRICATION OF SPECIMEN HOLDING ARRANGEMENT

3.1 SLURRY EROSION TEST:

The method used for testing the erosion wear rate under varying experimental conditions is known as slurry erosion test .This is carried out by using a slurry erosion tester. The test is carried-out by measuring the loss of mass of the specimen by weighing it before and after the process in the tester.

3.1.1 SLURRY EROSION TESTER:



1. Sample Holder
2. Samples
3. Shaft
4. Container
5. Electric Motor
6. Pulley

3.2 CONSTRUCTION:

The slurry erosion tester as shown consists of the parts as shown in the figure above.

The samples or specimen are fixed on a disc along its circumference through the holding arrangement, which is attached to the shaft. The assembly is immersed in the container drum containing the slurry. Other end of the shaft is attached to a pulley supported by the bearing arrangement. At a certain distance from the shaft there is a bracket, which holds the motor, & there is another pulley on the motor shaft. A belt connects these two pulleys. So that when the motor starts rotating the shaft holding the samples will also rotate.

3. 3 WORKING PRINCIPLE:

The specimen to be tested are first thoroughly cleaned and weighed in using a precision weighing machine. These specimens having a standard size are fixed onto the disc with the help of clamps at the desired radial distance. The disc along with the specimen are dipped into the slurry contained in the container. The motor is then started and the specimens are rotated at the desired speed for a given duration. The specimen are removed, cleaned and weighed after the test is over.

The loss of mass of the specimen during the test is found out. The rate of erosion is calculated as the rate of loss of mass with respect to various experimental parameters.

3. 4 EXPERIMENTAL PARAMETERS:

The various experimental parameters that have to be varied during the test are:

1. Slurry concentration
2. Speed of rotation
3. Distance traversed
4. Time

3.5 FABRICATION OF THE SPECIMEN HOLDING ARRANGEMENT

The specimen holding arrangement has the following components:

1) A spindle of diameter 12mm and length 120mm
2) A metal strip of length 210mm, width 20mm and 5mm thickness
3) Two cylindrical metal pieces having cylindrical slots for holding cylindrical specimen
4) Two cylindrical metal pieces having rectangular slots for holding rectangular specimen.

The material used for whole arrangement was mild steel.

3.5.1 Fabrication of the spindle:

The spindle was made from a piece of mild steel of length 120 mm and 15 mm diameter by turning it in a lathe into a diameter of 12 mm for a length of 100 mm and into a diameter of 10 mm for the rest of 20 mm length. After this operation, the part of the spindle having 10 mm diameter was threaded in a lathe.

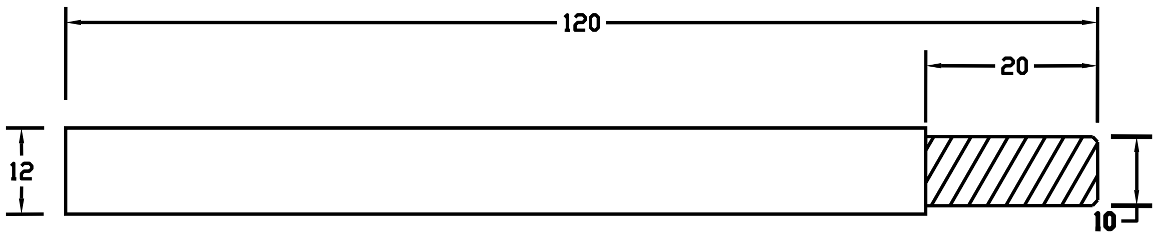


Fig 3.1 SPINDLE

3.5.2 Fabrication of the metal strip:

A metal strip having width 20 mm and thickness of 5mm was cut into a length of 210 mm. Three holes of diameter 9mm were drilled on the metal strip, one at the center and two at a distance of 90mm from the center at either side were drilled in a universal drilling machine. The hole at the center was made for fitting the spindle with it using a nut. The two holes at either side were made for fitting the specimen holders with it.

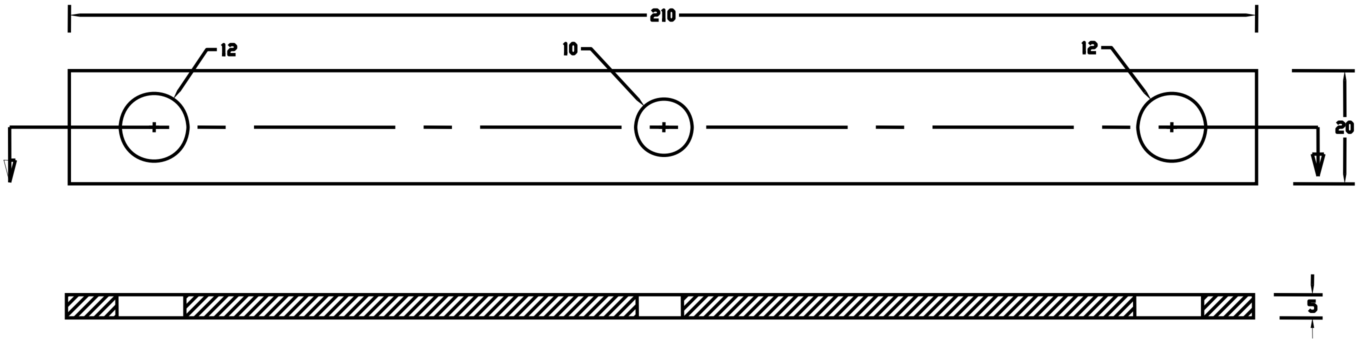


Fig 3.2 METAL STRIP

3.5.3 Fabrication of the cylindrical specimen holder:

For fabricating the cylindrical specimen holder a cylindrical piece of mild steel of length 80mm and 30mm diameter was taken. This was then turned into a diameter of 25mm for the whole length. Again this was turned into a diameter of 12mm for a length of 30 mm from one end of the piece. A hole was drilled along the axis of the job at the center of the face having larger diameter up to a depth of 30 mm. This hole was enlarged to a diameter of 18 mm by boring operation. A hole of 3 mm diameter was drilled with its axis perpendicular to the axis of the job at a distance of 10 mm from the face with larger diameter. This hole was again internally threaded by the reaming process. The portion of the job having smaller diameter was threaded with the help of a die.

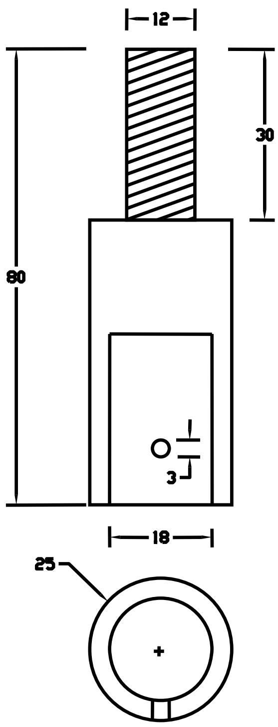


Fig 3.3

3.5.4 Fabrication of the flat specimen holder:

For fabricating the flat specimen holder a cylindrical piece of mild steel of length 80mm and 30mm diameter was taken. This was then turned into a diameter of 25mm for the whole length. Again this was turned into a diameter of 12mm for a length of 30 mm from one end of the piece. A hole of diameter 12mm was drilled along the axis of the job at the center of the face having larger diameter up to a depth of 30 mm. A rectangular slot of width 12mm and 30 mm depth was made along the hole. A hole of 3 mm diameter was drilled with its axis perpendicular to the axis of the job at a distance of 10 mm from the face with larger diameter. This hole was again internally threaded by the reaming process. The portion of the job having smaller diameter was threaded with the help of a die.

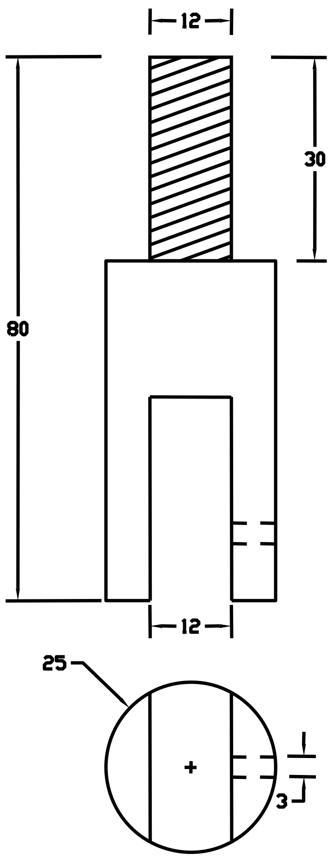


Fig 3.4

3.6 ASSEMBLY OF THE WHOLE ARRANGEMENT:

The spindle was fixed with the metal strip by putting its threaded end into the hole at the center of the metal strip and tightening a nut of appropriate size. The specimen holders of the required type (i.e. cylindrical or flat) were fixed with the metal strip at holes at the either sides of the strip by tightening them with a nut of appropriate size. Nuts of appropriate size were screwed into the internal threads made on the job. These are used for rigidly tightening the specimen into the slots during the experiment.

3.6.1 FOR FLAT TYPE SPECIMEN:

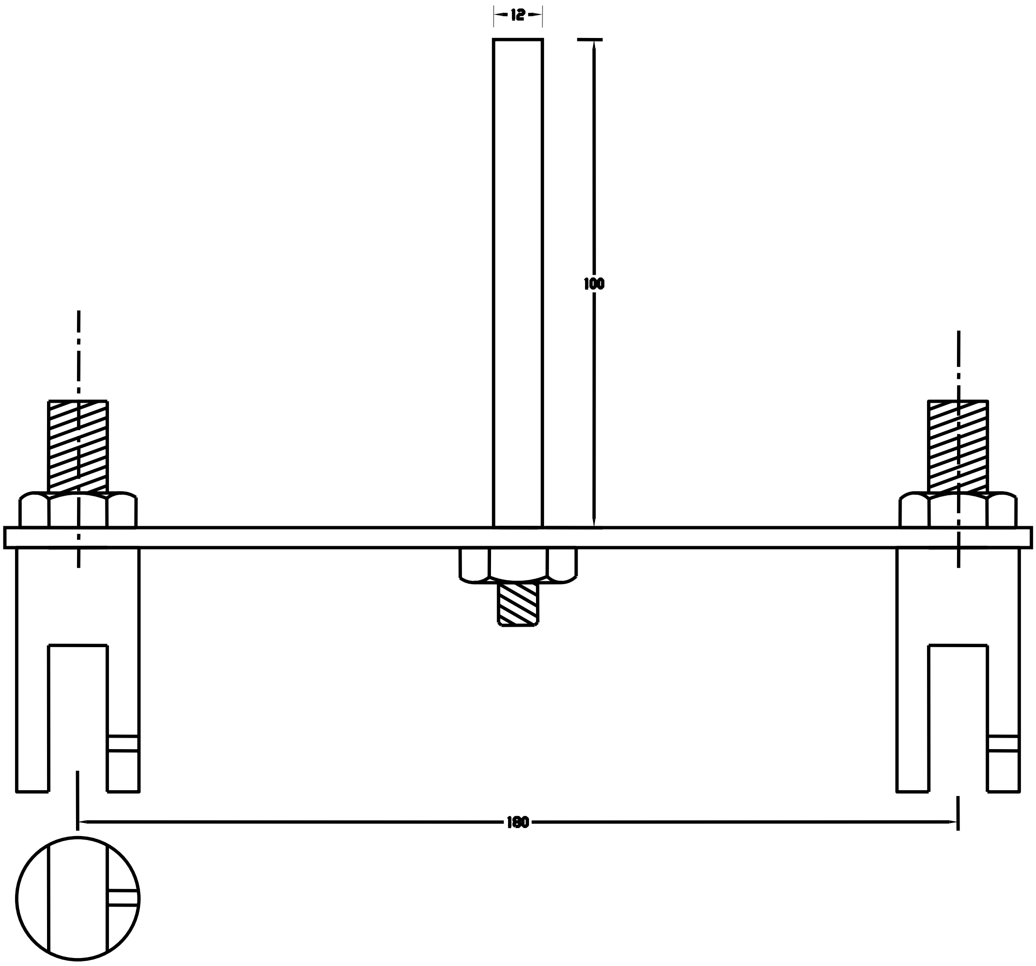


Fig 3.5

*3.6.*2 FOR CYLINDERICAL SPECIMEN:

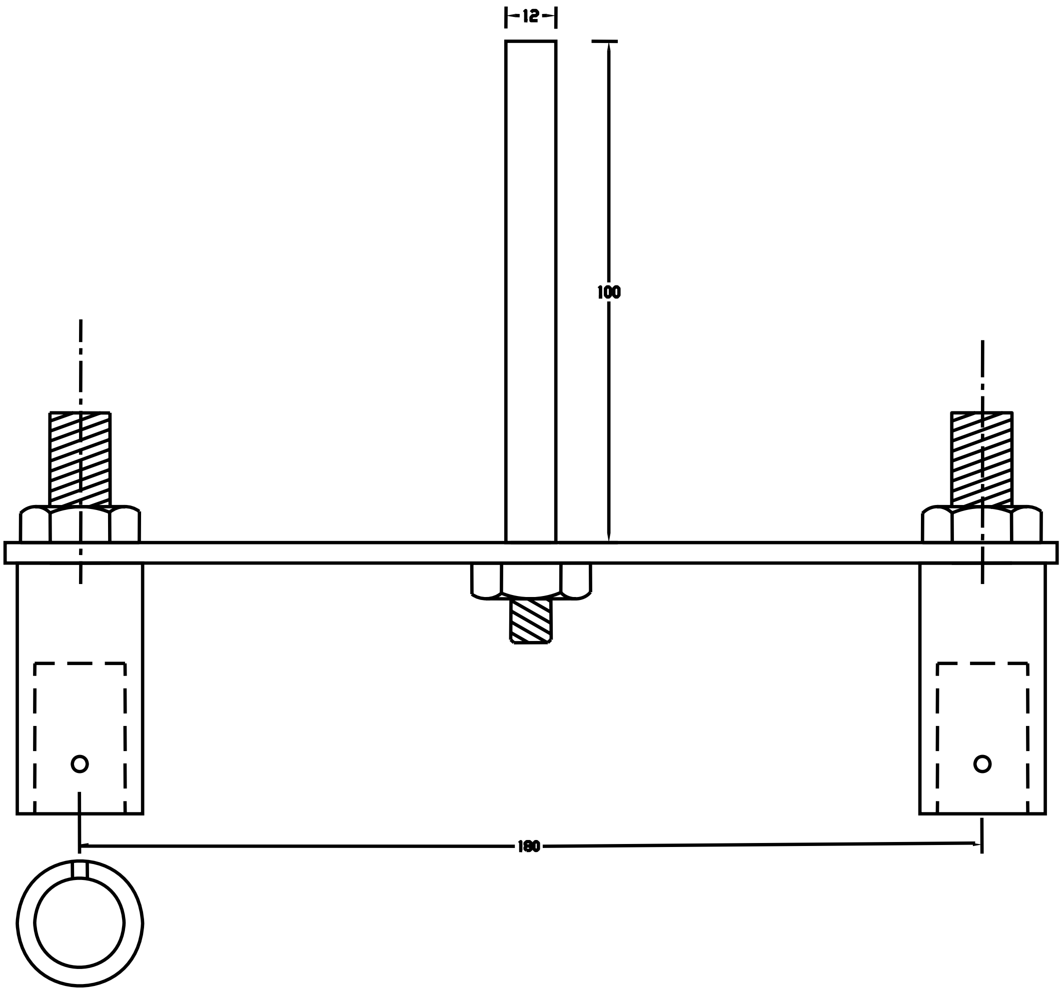


Fig 3.6

Chapter 4

RESULS AND DISCUSSION

The self made slurry erosion tester can be used to rank the slurry erosive resistance of solids. The test is performed by fixing the samples (rectangular, square or circular) on to a fixture attached with a shaft. The assembly is to be immersing in the container drum containing the slurry. The shaft is attached to a motor, which can be rotated at varying and predetermined speed. Materials such as metals, minerals, polymers composites, ceramics, coatings and heat processed samples can be tested with this instrument.

Test Variables:

1. Slurry Composition
2. Speed of rotation
3. Distance traversed

Measurement:

Mass loss method:

The sample can be weighed prior to and after a particular interval corresponding to a particular sliding distance, to find out the corresponding weight loss. The slurry wear rate (m^3/m) can be used for comparison.

SPECIFICATION:

Parameters	Unit	Nominal Values
Sample sizes	mm	(1)15 Dia, (2)50*30*5
No. of Samples	Nos.	2 per run
Slurry vessel size	mm	300 Dia, 250 Height
Speed	RPM	0-500

Fig 4.1 SLURRY EROSION TESTER

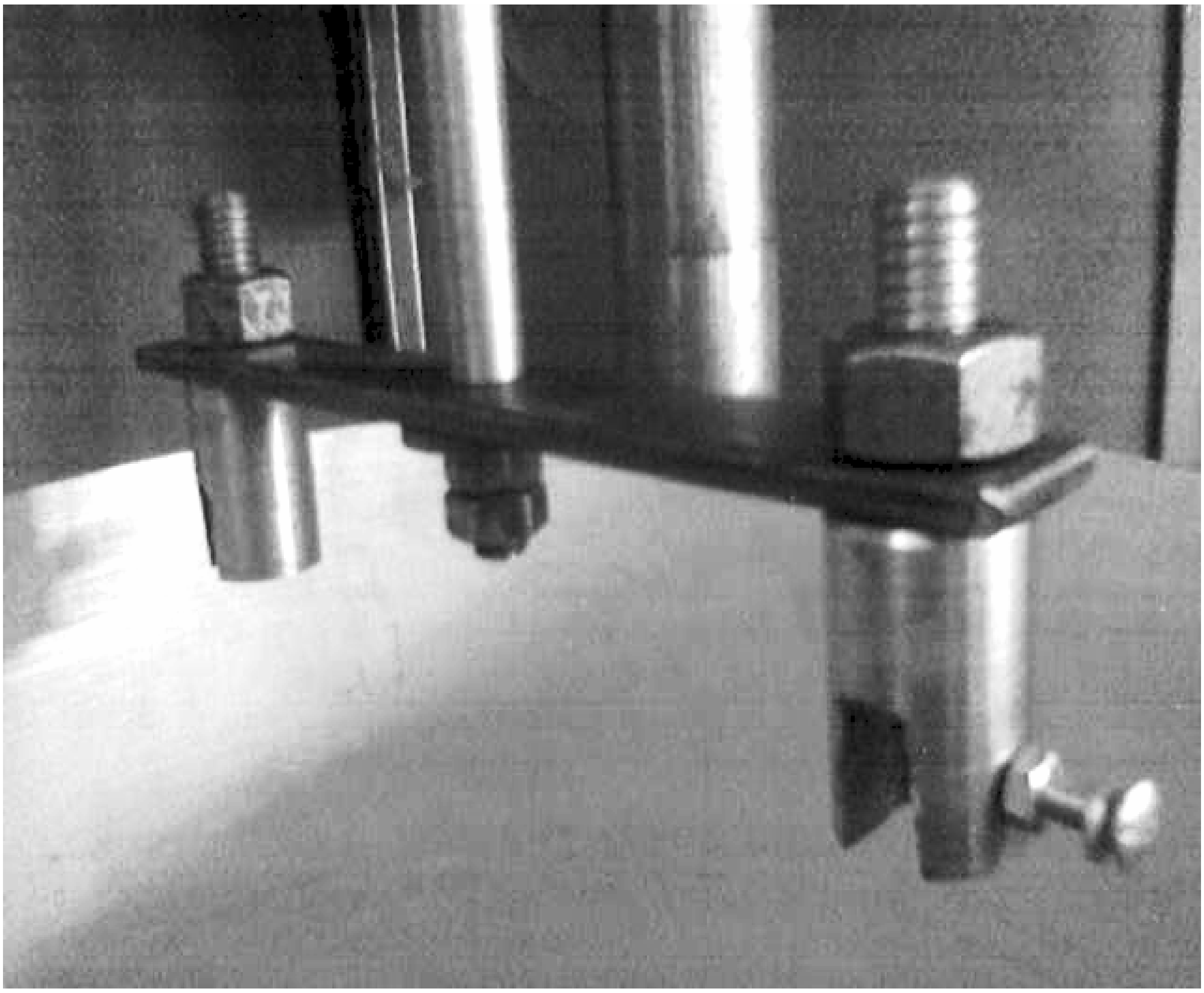


Fig 4.2 SPECIMEN HOLDING ARRANGEMENT

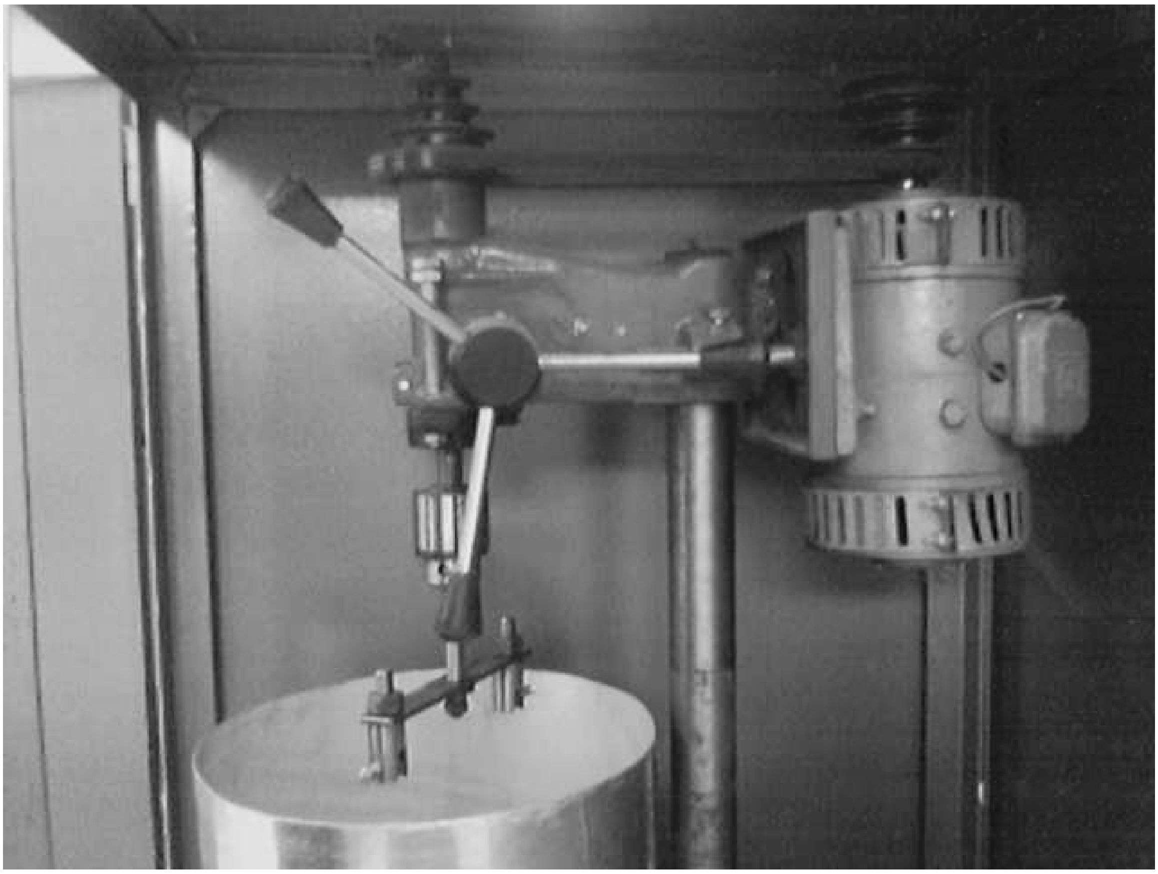


Fig 4.3 MECHANISM FOR MOVING SPECIMEN UP AND DOWN

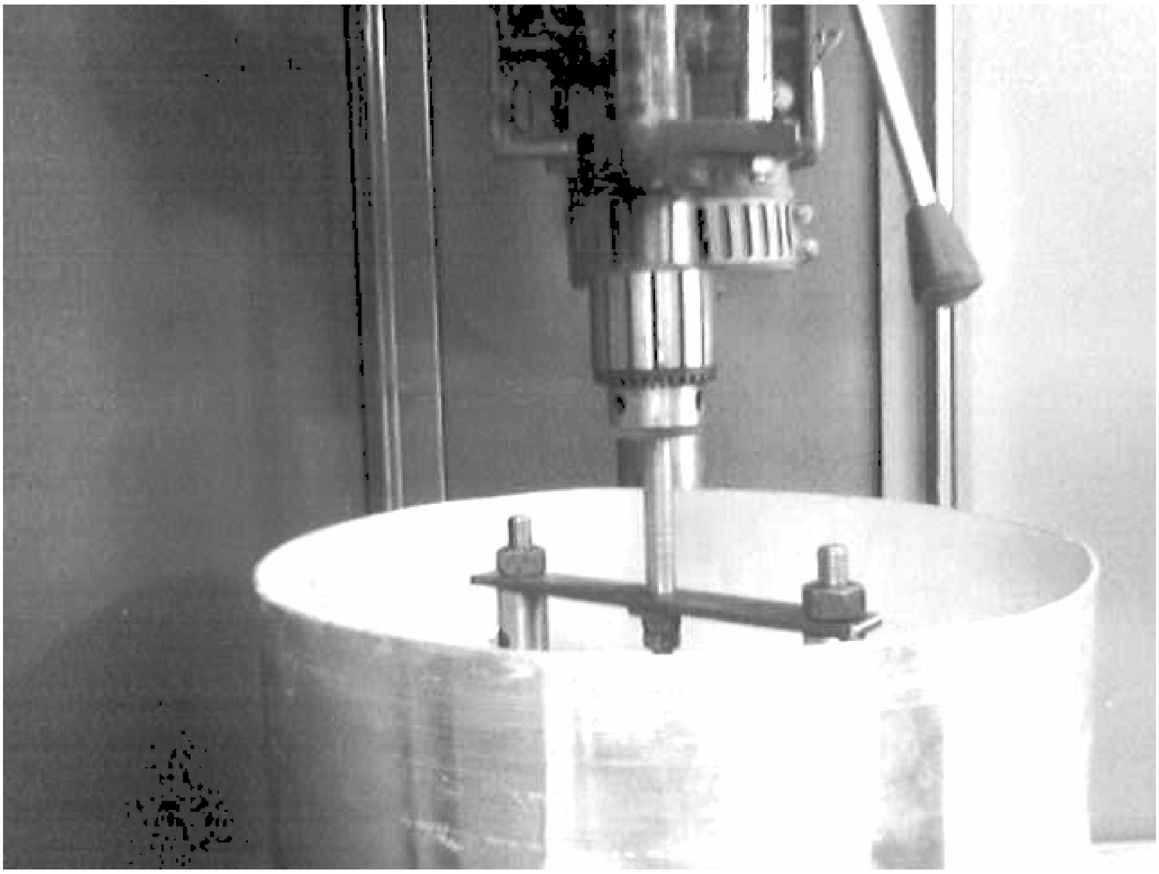


Fig 4.4 SPECIMEN IN THE LOWER POSITION DURING EXPERIMENT

Fig 4.5 CONTROL PANEL

CONTRIBUTERS:

Concept and set-up design

PROF.S.K.ACHARYA

Department of Mechanical Engineering

Design and developed by

Sri Gopal Krishna Nanda Roll No-10303059

Sri Samarendra Das Roll No-10403073D

Testing and standardization

Punyapriya Mishra

ME (Production)-2007

Fabrication:

Pee Pee Enterprises, Jagda

& workshop, Rourkela

Mechanical associated

Sri N.P.Barik, Mechanical Engg. Department

Sri Somnath Das Work Shop

Chapter 5

CONCLUSION

CONCLUSION

The slurry erosion tester has been successfully fabricated in the laboratory. Further it has been tested for proper functioning. Materials such as metals, minerals, polymers composites, ceramics, coatings and heat processed samples can be tested with this instrument. The self made slurry erosion tester can be used to rank the slurry erosive resistance of solids.

The machine can be used for finding out the wear characteristics of various materials which are being exposed slurry erosion. Different kinds of slurries can be used for finding the wear characteristics of the material, depending upon the kind of environment it is being exposed to. We conclude that the machine cost can be reduced manifold by fabricating the machine in the laboratory instead of buying the machine from the market.

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