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# DEVELOPMENT AND EXPERIMENTAL INVESTIGATION OF WEAR TESTING MACHINE

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**ABSTRACT**:
The purpose of this project was to develop and construct a pin-on-disc wear testing system that was both cost-effective and efficient. It is utilized in the area of metallurgical research. The purpose of this project is to investigate the application of friction on a pin into a circular disc, to control the speed using an electronic control unit, to load three different types of pins (Copper, Gunmetal, and Aluminum) into a circular mild steel disc, and to obtain results using the force applied, the duration of the test, and the speed of rotation. We can precisely determine the wear rate of materials based on their volume loss. The stress analysis is performed using finite element analysis (FEA) software on the pin on the disc wear tester. Because the accuracy of computed wear values is highly dependent on the state of tension and strain in the pin on the disc tester's components, correct modeling of the state of stress and strain is critical. The machine's design and calculations were developed, and it was constructed using carefully chosen materials and components obtained locally. The project's overall cost is Rs.12000. This project's breakeven point will be 120 pieces to recoup the cost. Additionally, the payback time (including just the savings in testing specimens) is four months, and the project's cost-benefit ratio is one to three. The pin on disc wear tester is critical for the creation of new and better cost-cutting applications; it is also widely applicable to the rest of the industry.
**Keywords:** Disc, Motor, Pulley, Belt, lever.

## INTRODUCTION:

Wear testing is a technique for determining if a substance has been eroded or displaced sideways from its "derivative" and original location on a solid surface due to the action of another surface. This test is often used to determine the workability of material in service. Because materials react differently when subjected to friction, it may be necessary to conduct mechanical experiments that mimic the conditions under which the material will be used. Typically, wear testing is conducted on the A356 alloy. Wear tests on the chosen alloy are a key criterion for evaluating the material's quality. These materials are subjected to compressive stresses and forces in service, and their ability to resist such pressures and forces without failure is a measure of their dependability. The presence of material wear testing equipment is the first step toward effective quality control and excellent production practices. Establishing quality control facilities for ongoing product quality evaluation is a critical need for guaranteeing compliance with applicable standards and sustaining product quality that continues to satisfy the requirements of ignorant consumers. There is currently no efficient locally manufactured wear testing equipment that is widely accessible and inexpensive to metallurgical researchers in India. Foreign wear machines are prohibitively costly, scarce, and beyond of reach of researchers. In response to the need to develop a dual-purpose effective wear machine that is made entirely of locally sourced materials and components, is inexpensive and readily available for surface study, improves productivity, quality control, and good manufacturing practices in the building material industry, and also stimulates national economic growth, the design and fabrication of a wear testing machine are being undertaken. We developed and built pin-on-disc wear test devices. Wear testing on a pin on discs is conducted by providing a continuous normal load to the contact while spinning the disc at a constant speed. Continuous weight loss is recorded and stored to determine the wear rate. The purpose of this research was to determine the impact of load variation on the rate of wear by developing a device to determine the rate of material removal under the influence of various loads.

**EXISTING PROCEDURE :**

As Baipramila. B.N. (1987) said wear is caused by interactions between surfaces, more precisely the loss and distortion of material from a surface as a consequence of the opposite surface's mechanical action. Metals wear due to the plastic displacement of surface and near-surface material and the separation of wear debris particles. The produced particles range in size from millimeters to ions. Contact with other metals, nonmetallic solids, flowing liquids, or solid particles or liquid droplets entrained in flowing gasses may cause this process to occur. According to Basavarajappa. C, (2006), wear may also be described as a process in which contact between two surfaces or boundary faces of solids within the working environment leads to dimensional loss of one solid, with or without actual decoupling and material loss. Wear-related factors in the working environment include loads and features such as unidirectional sliding, reciprocating, rolling, and impact loads, as well as speed and temperature. They also include different types of counter bodies such as solid, liquid, or gas, and contract types such as single-phase or multiphase, the latter of which may combine the liquid with solid particles and gas bubbles.

**OBJECTIVES :**

To design and develop a circular work on disc wear tester that is both cost-effective and efficient (pin on disc) for use in the area of metallurgical research. This research aims to investigate the application of the friction principle to the circular disk on a task.

**SCOPE :**

This test method provides a laboratory technique for determining the use of a pin-on-disk device in sliding materials. Materials under supposedly not abrasive circumstances are evaluated in pairs. The main areas of experimental focus for this kind of device are outlined to assess the wear. The friction coefficient may also be calculated. The values shown in SI units should be considered as standard. This standard is not intended to address all safety issues related to its usage if any. The user of this standard is responsible for establishing suitable safety and health procedures and establishing before using the application of regulatory restrictions. i. For tensile strength, corrosion resistance along with certain electrical and thermal measurements, the composites produced may be further examined. It helps to expand your field of applicability in many technical designs and applications. ii. Composite wear behavior may be further studied under various ambient circumstances, such as lubrication and corrosive situations where a change of the temperature can be done. iii. The effect of heat treatment on composites' wear characteristics may also be studied to have broader applications. iv. To investigate the potential of utilizing rutile strengthened composites for various military purposes, the high-stress rates of the produced composite may be identified.

**MATERIALS AND METHODS :**

This chapter elaborates and explains in detail the materials and techniques involved in the design and manufacture of the pin on a disk wear testing equipment for three distinct specimens.

**Design of the concept:**

Based on the research carried out via the supplied component drawing, the pin on the disk wears testing machine was developed for the safe and simple operation of three distinct models (Francis.E.Kennedy, 2015).

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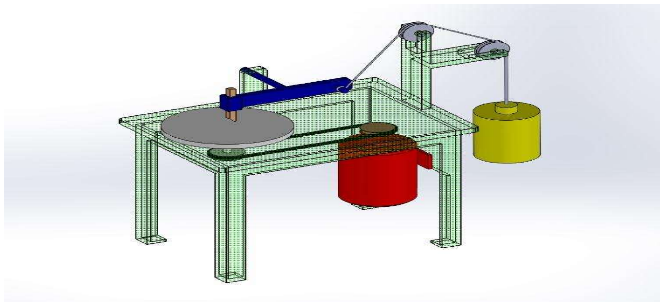


**Figure.1 Conceptual view of Wear Testing Machine**

## VARIOUS PARTS OF CONCEPTUAL DESIGN

The different project models were created using the 2018 edition of the program solid works. Different components are initially designed in the fundamental research. The material for the body is chosen once the fundamentals have been examined. The components are intended to have excellent life and operate for the target product. The design of the wear testing machine includes the design of the following different components. Table 3.1 illustrates the different project components and functions of each component (Gun.Y.Lee,2002).

**Table 1 Components and functions**

| S.no. | Components | Functions |
|---|---|---|
| 1 | Tool | Physical material is used to determine the wear rate. |
| 2 | Table | It is used to support the experimental setup. |
| 3 | Load | It supplies the required workload to the tool. |
| 4 | Pulley | It is used to support movement and transmit power. |
| 5 | Motor | It is used to convert electrical into mechanical energy. |
| 6 | Lever | It is used to hold the tool steadily over the disc. |
| 7 | Rotating disc | It creates friction at the point of contact of the tool. |
| 8 | Belt | It transmits the force from the motor to various components. |

## DESIGN OF TABLE:

The frame is intended to be loaded with 50kg. The L-angle is utilized to build the frame structure. To cover the bottom and sides of the frame, sheet metal is required. The material selected for the frame is „mild steel," because the fittings must withstand the damage caused by wear testing (Fitch. C, 2009).

**The calculation for the thickness of sheet metal is as follows:**

Yield strength for mild steel = 248 MPa

= 248 N/mm$^2$

Load capacity = 2 ton

= 2000 kg

= 2000 * 9.8 = 19.6 KN
Width of the plate = 750 mm
A factor of safety = 10

Stress (σ) = P/A
19600/750*t = 48
The thickness of the sheet metal = 1.0537 mm
For more safety = 3.048 mm is selected
= 11gauge is selected

**THE CALCULATION FOR THE L - ANGLE IS AS FOLLOWS:**

Yield strength for mild steel = 248 MPa
= 248 $N/mm^2$
Load capacity = 2 ton
= 2000 kg
= 2000 * 9.8= 19600 N
Area = (292 * t) $mm^2$
A factor of safety = 5
Stress (σ) = P/A
19600/292*t = 248
The thickness of the sheet metal = 1.198 mm
For more safety = 2 mm is selected
For standard dimensions, = 50mm * 50 mm * 2mm is Selected
The dimensions of the L – angle plate is = 50 * 50 * 2 mm
The dimensions of the frame are = 466.4* 669.9 * 553.4 mm
The sheet metal thickness for the bottom = 3.048mm
= 11 gauge

**Table 2 Specification of table**

| **Specification** | **Dimensions** |
|---|---|
| Length | 466.40 mm |
| Breadth | 669.60 mm |
| Height | 553.4 mm |

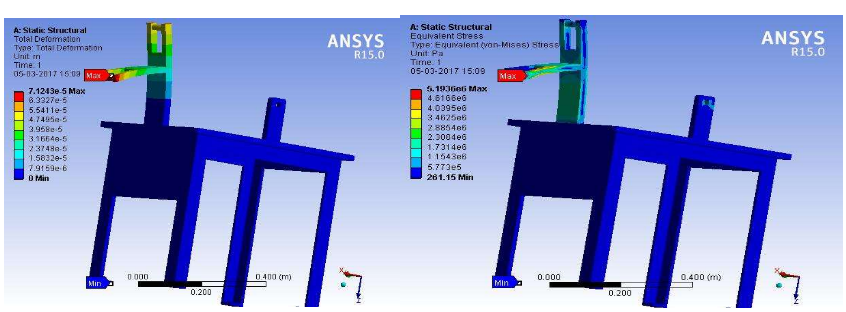



**Figure.2** Stress and Deformation Analysis of Tabl

**DESIGN OF MOTOR:**

The engine used in the wear testing machine is a single-stage induction motor, as a low-voltage engine, the speed may vary according to our requirements. An AC engine is an electric motor powered by an alternating current (Yung. C, 2008).

Output power in HP = (2 x Π x NT)/4500
Torque = Load x distance moved
Load = 10 Kg
Distance moved = 0.1 m
Torque = 10 x 0.1= 1 Kg-m
∴Required output power in HP = (2 x Π x NT)/4500
= (2 x Π x 550 x 1) / 4500
Hence power required for the motor = 0.768 ≈ 1 HP

**THE CALCULATION FOR DESIGN OF SHAFT RADIUS OF MOTOR IS:**

Maximum bending stress, B = (M * r) / I …..(1)
I = π/64* d4
= π*r4*0.25
= 0.785*r4 …….(2)
40 = (66666.67 *r)/ (0.785*r4) R = 12.85 mm
So, the minimum radius of the shaft should be 12.85 or 13 mm.

**DESIGN OF ROTATING DISC :**

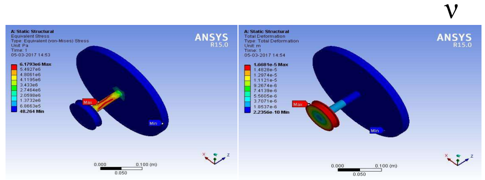
A spinning disk consisting of mild steel is used for wear testing and is approximately 200 mm in diameter and about 10 mm thick. Mild steel disk is more flexible, especially in situations where flexibility is necessary and harder steels are too brittle (Xuan. J.L, 2009). Mild steel is excellent for mechanical engineering and manufacturing for general purposes. Its strength makes it an excellent material option for the building of cages, frames, fences, and other applications where the stress is not severe (Lawrence. L, 2015). Bright, mild, cold steel with a higher esthetic appeal offers stronger sectional tolerances and higher straightness. Mild steel offers a significant boost in physical strength compared to ordinary mild steel, making it a superior option for more demanding applications.

**DESIGN OF DISC FOR STABILITY IN DEFLECTION:**

Deflection, Y = P / 48 E1
Length, L = 300 mm
Young"s modulus, E = 2.08 x 105
Moment of inertia, I = bd3/12
= 400*(30)3/12 = 9 x 103 mm4

**CALCULATING THE LOAD ON THE DISC (P):-**

Maximum load acting at the center of plate at 5Kg / cm2 = 430kgf
Maximum load acting at the center of the plate at 7Kg/cm2 = 430*7/5 = 602 Kgf.
Load distributed to the front half of the plate, P = 602/2 = 3010 N
Deflection of plate at maximum, ν = PL3/48EI
= (3010) $(300)^3$ (301) /(48*(2.08*105(9*103))
ν = 9.04 x 10-3mm




**f.3** Stress and Deformation Analysis of Disc

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**DESIGN OF LEVER:**

The lever is constructed of mild steel, the pulley is connected to the center of the lever at the end and the frame construction is attached to the other end. It may thus travel up and down the movement. The heel has two ends, one with a specimen container and the other with a metal wire where the loads are hung down. The lever is pulled up or down from the center to the primary support (Williams, J. A.2005).

| | | |
|---|---|---|
| The required length to attach the sample holder | L1 | = 102 mm |
| The required length to attach the Flexible Arm to metallic wire, | L2 | = 102mm |
| The total length of the lever is, | L | = L1 + L2 |
| | | = 204 mm |
| The width of the lever is, | B | = 10 mm |

**Table 3 Specification of the lever**

| Specification | Dimensions |
|---|---|
| Length | 204 mm |
| Height | 280 mm |
| Width | 10 mm |

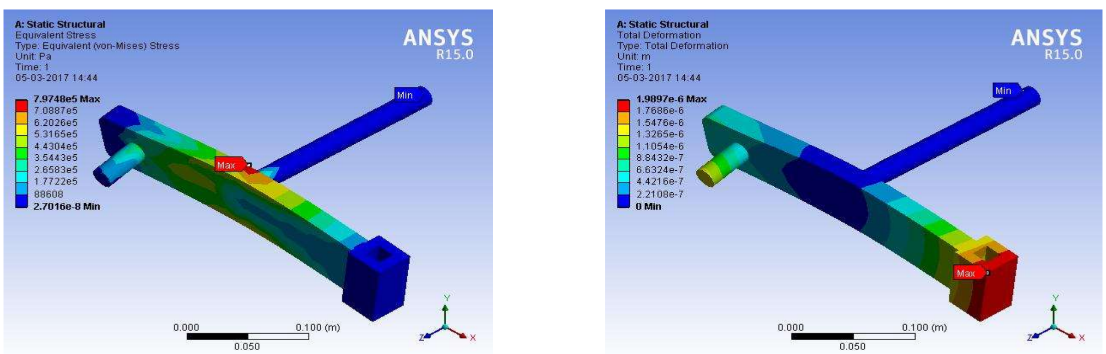


**Figure.4** Stress and Deformation Analysis of Lever

**DESIGN OF PULLEY:**

A pulley is a wheel on an axle or shaft that supports the movement and change of direction of a tight cable/belt. Pulleys are used for lifting weights, for applying forces, and for transmitting power in various ways. A pulley's purpose is to raise heavy items via a change of force direction on a flexible rope. It also includes a wheel with a groove and an axle on its external edge. A pulley facilitates lifting things upward with the assistance of cables, chains, or cords. The direction of the power needed to raise an item is shifted from the push to the pulley system. The squirrels are produced to make heavy labor more bearable and categorized as mobile, stationary or mixed. The force required to raise or draw the weight may also be decreased by many pulleys. Pulley helps to distribute the weight equally lightens the lift. A belt and pulley system has two or more pulleys in common to a belt. This enables the transmission of mechanical power, torque, and speed across axles. When the pulleys have different diameters, there is a mechanical benefit.

**SPEEDS IN PULLEYS:**

**Measured Specifications:**

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| | |
|---|---|
| N1/N2 | = D2/D1 |
| N1 | = Input speed to the Motor = 1440 rpm |
| N2 | = Output speed from the pulley-2 |
| D2 | = Diameter of the pulley-2 = 50.8mm |
| D1 | = Diameter of the Motor pulley= 25.4mm |
| N2 | = (D1/D2) x N1 |
| | = (25.4 /50.8) x 1440 |
| N2 | = 720 rpm. |

**DIAMETER OF DRIVEN PULLEY :**

$D_2 = D_1 N_1 / N_2$

= (25.4*1440)/720

= 50.8 mm

**Table 4 Specification of pulley**

| Specification | Dimensions |
|---|---|
| Outer Diameter | 80 mm |
| Inner Diameter | 20 mm |
| Sleeve Length | 12 mm |

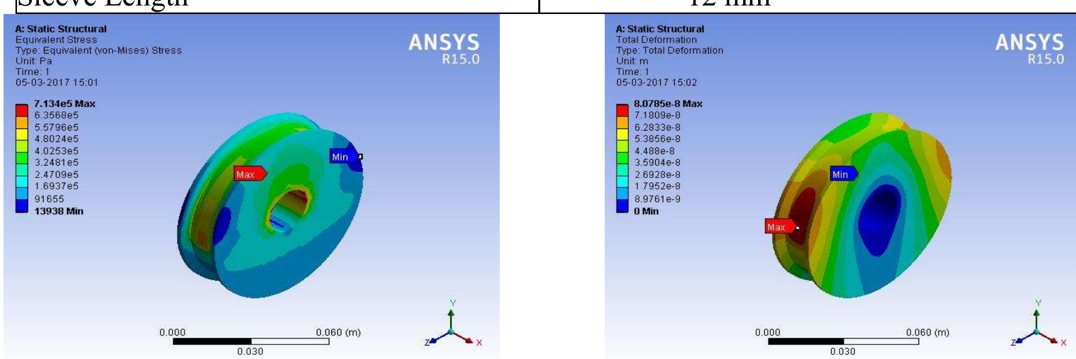


**Fig.2.5** Stress and Deformation Analysis of Pulley

**DESIGN OF BELT :**

A belt is a loop of flexible material that mechanically links two or more spinning shafts, usually parallel. Belts may be employed as a source of movement, efficient power transmission, or relative motion tracking. Belts are wrapped over pulleys, and the pulleys may spin and the shafts do not need to be parallel. The belt may either drive the pulley in one way (either the same if on parallel shafts), or the belt can be crossed to reverse the direction of the driven shaft. Belts are the cheapest power transfer tool between shafts that cannot be axially aligned. Specially engineered belts and pulleys accomplish power transfer. There are significant demands on a belt-drive transmission system and this has led to numerous variants in the subject. They operate smoothly, with minimal noise, a coil motor, and load-resistant roles even though they have less strength than gears or chains. However, belt technical advances enable the use of belts in systems that only previously permitted chains or gears.

The table 4 shows the dimensions of the material. Nominal pitch length of belt (L) $= 2C + \Pi/2 (D+d) + \{(D-d)^2/4C\}$

$= (2 \times 500) + \pi/2\ (50.8+25.4) + \{(50.8-25.4)^2/(4 \times 500)\}$

$= 1120$ mm

For 1120 mm, the belt selected is "A" type.

Centre distance of belt length (C) $= A + (A^2 - B)^{0.5}$

A $= (L/4) - \{\pi(D+d)/8\}$

$= (1120/4) - \{\pi(50.8+25.4)/8\}$

$= 250.09$ mm

B $= \{(D-d)^2/8\}$

$= \{(50.8-25.4)^2/8\}$

$= 80.64$ mm

C $= 500.01$ mm

$\approx 500$ mm

**THE TRANSMITTING CAPACITIES:**

KW $= (0.45\ S^{009} - 19.62 - 0.765 \times 10^{-4} S^2)S$

S-Speed of the belt $= (\pi d N_1/60) \times 1000$ in m/s

De-Equivalent Pitch diameter = dp x Fb

Dp-Pitch diameter of smaller pulley,

S $= (\pi \times 63.53 \times 720/60) \times 1000$

S = 2.39 m/sec de = 125 mm.

Fb = 1.12

According to D/d = 1.79,

dp = 111.6 mm

KW = 0.62

Are of contact angle $= 180^o - 60^o\ (D-d/C)$

$= 180^o - 60^o\ (50.8-25.4/500)$

$= 173.9^o$

$\approx 174^o$

Number of Belts $= \{(P \times Fa)/\ (Kw \times Fe \times Fd)\ \}$

Fa = Correction factor for industrial service = 1.2

Fe = Correction factor for Nominal length = 0.93

Fd = Correction factor for Arc of Contact angle = 0.76

∴ Number of Belt = 1.09 ≈ 1 Belt.

**Table .5 Specification of belt**

| **Specification** | **Dimensions** |
|---|---|
| Diameter | 300 mm |

| | |
|---|---|
| Material | Rubber |
| Thickness | 20 mm |

**ASSEMBLED VIEW:**

The assembled view of the wear tester consists of the wear tester being fully assembled. The assembled wear tester is completely developed. Figure.6 shows the assembled view of the produced model.

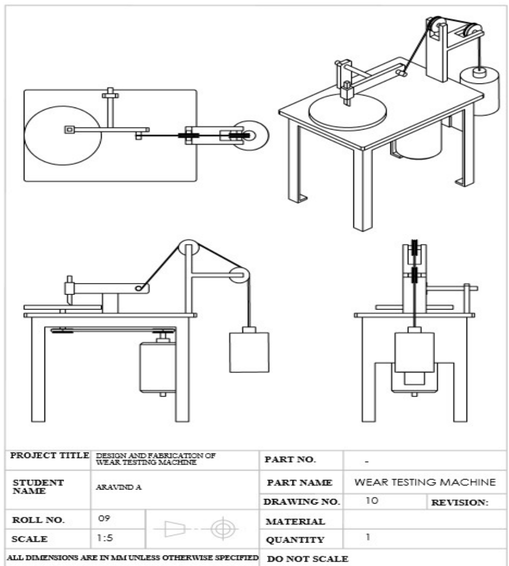


**Figure.6 Assembled view**

**FABRICATED PROTOTYPE:**

The wear machine comprises a load frame and a control unit electric motor. A steel wire links the flexible arm to the electromagnetic key, which acted as a brake to halt the experiment at the necessary moment and regulated the time by a digital timer. The load changes by altering the weight and weight placement (Sudarshan. M.K, 2005). The wear test on pin-on-disc devices is illustrated in Figure 1. The flat end of the cylindrical specimen was locked at a diameter of 8mm and a length of 12mm in chuck jaws so that samples could not rotate in the test. Axial load was supplied to the pins against the spinning disk flat surface. The ends of the specimen were polished and cleaned using 1200 gray SiC emery paper and acetone. The wear test is the average of two measurements and was performed at room temperatures. The standard disco was constructed of ASE 1045 hard steel with 263BHN hardness and surface roughness of 0.2 µm. The materials used for this research were A356 with the chemical composition shown in Table 2. The content was received as a bar. Each specimen was weighed before and after the experiment using a digital balance of 0.001gm. The experiment length was regulated by a digital timer (Mahapatara. S.S, 2009).

**Table 6 Chemical composition of A356**

| **From** | **Chemical compositions (wt %)** |
|---|---|

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| | Si | Fe | Cu | Mg | Mn | Ni | Zn | Ti | Al |
|---|---|---|---|---|---|---|---|---|---|
| **Values** | 6.72 | 0.25 | 0.11 | 0.27 | 0.002 | 0.001 | 0.04 | 0.043 | Balance |

The average value of the weight loss percentage as a function of test time was calculated. From the weight loss of the specimens (Δm), it is possible to evaluate a dimensionless parameter known as w, "wear rate" define by Archard's equation.

$$W = \frac{m}{\rho \cdot v \cdot t \cdot A}$$

Where: Δm = weight loss (g), ρ = average density of material, t = test time (s) and

A = apparent contact area ($mm^2$).

**TESTING:**

The Pin-on-Disc testing technique for tribological characterization was utilized in this research. The testing is as follows (Williams, J. A.2005).

i. The pin surface was initially flat such that it supports the load across the whole cross-section termed the first phase. The surfaces of the pin sample floor with emery paper (80 grit size) were obtained before testing.

ii. In the following step/second stage, run-in-wear was performed. This phase prevents the early tumultuous period of friction and wears curves.

iii. End/third step is the real test known as constant/state wear. This is the dynamic rivalry between processes of material transfer (transfer of material from pin onto the disc and formation of wear debris and their subsequent removal).

iv. Precautionary measures were performed before the commencement of each experiment to ensure that the load was delivered in the usual direction.

**RESULTS & DISCUSSION:**

The findings obtained while manufacturing the pin on the disk wear testing equipment are described in-depth in this chapter. The specification, the table, and the cost analysis were addressed here as well.

**PIN ON DISC WEAR TESTING MACHINE:**

The prototypes were manufactured using excellent and industrial procedures. The manufacture of the prototype was described above. The prototype has been developed to improve performance during operation (Tao.D, 2004).

To investigate the use of the materials, the wear process must be simulated in a controlled way and the impact on several samples with the same test circumstances examined. A pin-on-disk test is one method to conduct wear. In this test, the research sample is placed on a spinning disk and a pin comes into contact with the surface of the sample and has a known wear force. A flat-shaped indenter is loaded with a precisely known force onto the test sample. The pin-shaped penetrator is placed on a robust lever which is intended as a frictionless force transducer.

The resultant friction forces acting between the pin and the disk are measured as the disk is spun. A pin for wear loss assessment offers many unique benefits Many vendors can easily supply pins with a broad range of materials. Their repeatability and quality may be outstanding for simple comparison. Assessing pin wear gives wear information at the contact point that is loaded during the test period. This compares to the basic material that only wears for a very short length of time. Wear tests are

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performed to determine wear performance and to examine the process of wear. The conceptual design prototype produced is illustrated in Fig.6 below.

**FABRICATED PROTOTYPE:**

A dry sliding wear test was performed on the pin-on-disk machine for various samples. The pin was pressed against the counter-side of a spinning disk with a wear track diameter of 200 mm. A dead-weight loading mechanism loaded the pin against the disk (Mustafa Taskin et al, 2007).

**Figure.7 Fabricated WTM**

Wear is a process through which one or both solid surfaces are removed in solid-state contact. Since wear is a phenomenon of surface loss and happens mostly on external surfaces, surface modifications of current metals are more convenient and cost-effective than adopting wear-resistant alloys. Before the test, slides were used for surfaces of the pin samples using emery paper (80 grains in size) to provide efficient contact between the fresh and smooth surface and the steel disc. The wear rate was estimated based on the method of height loss and represented as wear volume loss per unit sliding distance (Sachin. Y, 2005). Table 7 includes the prototype specification.

**Table .7 Specification of the prototype.**

| Specification | Values |
|---|---|
| Overall length | 609.6 mm |
| Overall breadth | 406.4 mm |
| Overall height | 711.2 mm |
| Overall weight | 15KG |
| Material | Mild steel |

In this experiment, the test was conducted with the following parameters:

i. Force
ii. Speed
iii. Time

In this experiment, the parameters such as speed, time, and load for all trials vary. The samples are carefully cleaned with acetone. A digital balance with a precision of ± 0.1 mg is then used to weigh each sample.
The sample is then placed on the tribometer pin holder ready to be wear-tested. Table 4.2 includes the pin parameter for the disc wear test machine.

**Table .8 Parameters of wear test**

| **Parameters** | **Variables** |
|---|---|
| Pin material | Copper, Aluminum, Gunmetal. |
| Disc material | Mild steel |
| Force | 10N, 20N,30N |
| Speed | 800,1000,1200 (rpm) |
| Time taken | 10, 20,30 (min) |

i. Measure the pin length before tightening it into the wear testing device using a Caliper vernier.
ii. Turn the engine plug and adjust the engine speed in the speed controller.
iii. Remove the pin and measure the pin length following the experiment iv. Repeat steps 1 to 3 with various pin materials (Copper, Aluminum Gunmetal), and the data were collected
In addition, weight loss of each specimen was achieved by weighing a single electronic weighing machine with an accuracy of 0.0001g before and after experimentation after complete acetone cleaning. The findings for different parameter combinations were acquired via the experiment. The dry sliding wear test was carried out using three parameters load, sliding speed and sliding distance, and three stages.

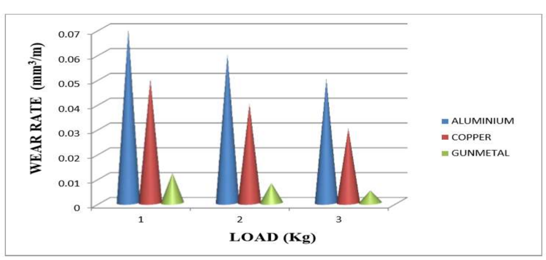
**TABULATION** :
The wear rate and wear resistance of aluminium, copper, and gunmetal had been tabulated under varying force, speed, and time is taken. The table 9 comprises tabulation of the project.

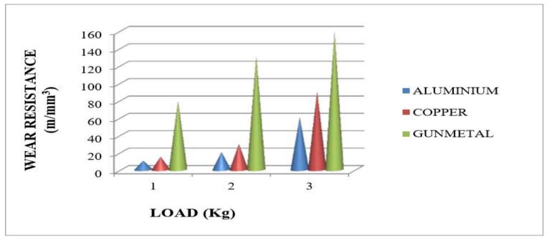
**Table.9 Specimen Details**

| MATERIAL | FORCE (N) | | | SPEED | | | TIME TAKE | | | | | | MEAN WEAR | | | | MEAN WEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_1$ | $F_2$ | $F_3$ | $S_1$ | $S_2$ | $S_3$ | $t_1$ | $t_2$ | $t_3$ | $W_1$ | $W_2$ | $W_3$ | W | $R_1$ | $R_2$ | $R_3$ | R |
| | 10 | 20 | 30 | 800 | 800 | 800 | 10 | 20 | 30 | 0.07 | 0.04 | 0.01 | 0.0687 | 14.12 | 27.78 | 73 | 10.41 |
| ALUMINIUM | 10 | 20 | 30 | 1000 | 1000 | 1000 | 10 | 20 | 30 | 0.7 | 0.03 | 0.01 | 0.0551 | 1.43 | 29.23 | 96.15 | 20.34 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 20 | 30 | 1200 | 1200 | 1200 | 10 | 20 | 30 | 0.69 | 0.03 | 0.01 | 0.0491 | 1.45 | 32.25 | 102.04 | 60.76 |
| COPPER | 10 | 20 | 30 | 800 | 800 | 800 | 10 | 20 | 30 | 0.02 | 0.05 | 0.02 | 0.0485 | 10.17 | 19.96 | 58.83 | 5.67 |
| | 10 | 20 | 30 | 1000 | 1000 | 1000 | 10 | 20 | 30 | 0.1 | 0.05 | 0.02 | 0.0339 | 10.36 | 20.08 | 61.34 | 29.75 |
| | 10 | 20 | 30 | 1200 | 1200 | 1200 | 10 | 20 | 30 | 0.09 | 0.05 | 0.02 | 0.0337 | 10.72 | 21 | 62.11 | 90.39 |
| GUNMETAL | 10 | 20 | 30 | 800 | 800 | 800 | 10 | 20 | 30 | 0.01 | 0.08 | 0.07 | 0.0126 | 73.52 | 99 | 153.84 | 79.58 |
| | 10 | 20 | 30 | 1000 | 1000 | 1000 | 10 | 20 | 30 | 0.01 | 0.06 | 0.05 | 0.008 | 77.51 | 131.57 | 188.67 | 131.5 |
| | 10 | 20 | 30 | 1200 | 1200 | 1200 | 10 | 20 | 30 | 0.01 | 0.01 | 0.04 | 0.005 | 87.71 | 163.93 | 285.71 | 209.4 |

**Wear calculation :**
Area = πr2 = $\pi(0.75)^2$ = 1.76 $mm^2$
Volume loss = (Mass loss, (g) / Density, ($g/cm^3$) ) * 1000 = ( 0.0194 / 2.7 )*100 = ( 7.185)*1000 = 7.185 mm3
Wear rate = Volume loss / Sliding distance = 7.185 / 12.5 = 0.5748 $mm^3/m$
Wear resistance = 1 / Wear rate = 1 / 0.5748 = 1.45 $m/mm^3$
**Specimen wear rate under various loads :**
The wear rate was shown for Aluminum, Copper, and Gunmetal. The diagram illustrates the rate of wear of various specimens under different load situations. Fig.4.2 consists of specimen wear rates at various loads (Yang. L.J, 2005).
**Wear specimen resistance at various loads:**
The aluminum, copper, and gunmetal wear resistance were evaluated. The graph illustrates the wear resistance of several specimens under different load levels. Figure.8 includes the wear resistance of specimens at various loads.






**Graph.1 Wear Rate Analysis**

**Analysis of costs :**

The study includes three distinct methods: payback, breakeven point, and benefit/cost ratio.

**Period of payback:**

Pay-back is the moment when an investment's original cash expenditure is anticipated to be repaid from the cash inflow from the investment. It is one of the easiest methods of investment assessment. Payback period = Initial investment per period. Cash inflow. Investment initial = Rs.12000. Expected cash inflow = Rs.3000/month. The term of payback = 12000/3000 = four month. The investment may be recovered within four months**.**

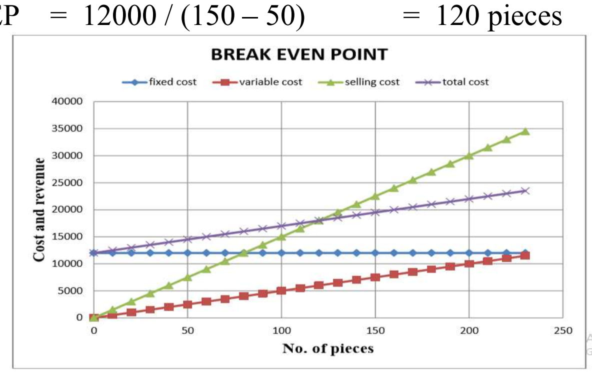
**Cost/benefit ratio:**

A Beneficiary-Cost Ratio (BCR)/Profitability Index Rate is an indicator used in the formal cost-effectiveness analytical field to try to describe a project or proposal's overall value for money. B / C = Sales estimate / Cost estimate = 36 000 / 12000 = Rs.3 The advantage is Rs.3 for every rupee spent on the project.

**Point Breakeven:**

The point of zero loss or profit is break-even. The company's revenues at break-even point are equal to its entire expenses and its contribution margin equals its total fixed costs. By way of the equation, contribution method, or graphical approach, a break-even point may be determined. This shows the entire cost connected with each potential output level, the fixed cost curve (FC) showing expenses not variable from the output level, and, lastly, different total income lines showing the total income obtained at each output level given the price that you will be charging.

Total fixed cost, F = Rs.12000 Sales piece per unit,
S = Rs.150 Variable cost per unit,
V = Rs.50 Breakeven point,
BEP = F/ (S-V)
BEP = 12000 / (150 – 50) = 120 pieces




**Graph.2 Cost Analysis**

**SUMMARY AND CONCLUSIONS:**

**Project benefits:**

Pin-on-disk wears testing may mimic various wear modes, such as one-way, two-way, one-way, and quasi-rotational. Mass loss assessment and differential analysis of test fluids are usually done after testing to determine wear characteristics. A contact profilometer may also be used to assess changes in surface topography owing to joint. The post-test wear scars may also be assessed metallurgically. Testing may also include third-party wear debris for faster wear assessments. In a third body wear analysis element, the third body wear analysis may be carried out as part of a pin-on-disk project. By placing a third body particle in the test joint, a precise replica of a certain state may be produced (e.g. bone cement in the joint space). This test may also be carried out in scratched-surface wear analyzes by putting a developed scratch network on the disk before the pin-on-disk test. In this particular application, the effects of complicated, protracted wear are usually simulated by assessing a hard metallic layer. Using a stereoscope or a high magnification scan electron microscope, both pins and disks may be assessed based on the metallurgical analysis after testing (sem). This enables you to get a better understanding of surface conditions and any scarring.

**ACHIEVEMENTS:**

This project contributed to the collection of topics already researched. Various fundamentals of production and design were understood throughout the project. Various industrial processes and production standards have been examined. Different kinds of testing and their existing processes are examined and evaluated to carry out this project. Different production techniques have been researched and used. (Benal.S. Mahagundappa, 2007) These innovative high-capacity devices enable the testing of many material combinations on a single test frame at a time. The 12-station configuration also provides extra statistical assurance via examination of many samples per condition. The statistical method results indicated the accuracy range of the locally manufactured tester. In line with the standards organization criteria, a locally manufactured wear tester may be used to prove the quality of the alloy and will provide values that compare well with those in the standard (foreign) alloy wear tester under identical test circumstances. The wear rate is reduced with the load falling from 29.4 to 49 N. Also, when the duration rises from 240 to 120 seconds, the wear rate reduces. Considerable cost and time savings may be achieved by utilizing the local tester. It is an effective analytical tool that may be used to assess material wear behavior. If wear testing is required, element highly advises that you test your implants side by side with a predicate device to make sure that your submission has an 'apples-to-apples comparison. The wear test frames of Element are designed to easily test your device and its predicate side-by-side on a single frame, guaranteeing reliable and consistent results.

**FINDINGS :**

Wear produces a material loss in relative motion owing to abrasion and friction from the contacting surfaces. Wear resistance is evaluated in terms of the capacity of the material to protect against wear loss damage. The wear strength of aluminum metal with the addition of hard ceramic rutile particles has been enhanced in the current study. Aluminum, because of its low weight, greater strength with enhanced rigidity, and also custom electrical and thermal characteristics, is utilized as a composite matrix stage. A change in wear behavior, sliding distances under various loading situations of the rutile particle reinforced composites were observed. Wear rates of all composites have been found to rise by raising the load from 9.8N to 30N. SEM inspection of the worn surfaces shows unique patterns of grooves and ridges in a sliding direction running parallel to each other. At load 9.8N, the wear track reveals the development of a groove at the site of contact with the abrasive action of the asperities. The increasing depth and breadth of the grooves show the shift from moderate wear to serious wear with a greater load of 49N. The wear loss is due to the combination of adhesion and delamination under an increased load of 49N. Delamination wear is evident with increased load because of the oxide layer fragmentation covering the surface owing to the rapid oxidation of the contact layer of the metal surface. The increase in load alters the wear transition from moderate to severe material loss from the specimen. Wear tests are devoted to promoting a fundamental and practical understanding of the nature of the wear of materials. Things of broad interest vary from basic knowledge of wear processes to creative solutions to actual engineering issues. The results of the statistical techniques revealed the precision range of the locally produced tester. The locally manufactured alloy test may be used to certify the alloy quality according to Standards Organisation's criteria and to provide values that will match those from the standard (foreign) alloy wear tester under identical test circumstances. Considerable cost and time savings may be achieved by utilizing the local tester. It is an effective analytical tool that may be used to assess material wear behavior.

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