Original Research Article

DEVELOPMENT OF A LABORATORY METALLOGRAPHIC GRINDING/POLISHING MACHINE

ABSTRACT

This study centered on the development of a laboratory metallographic grinding/polishing machine using locally sourced materials and indigenous technology to help in polishing metals for production of a flat, smooth and mirror-like surface of any metallic materials in order to determine their physical structure using microscopy for metallographic examinations. The designed was made and 3-dimensional architectural design was done to obtain clear vision of the design; The laboratory grinding/polishing machine was fabricated using the following components: angle-bars, mild steel plate, electric motor, shaft, belt, pulley, coupling, side pulley disc; following the specified dimensions from the 3-dimensional drawing; assembling of the various components follows; and finally, tested and performance evaluation was equally done. In testing the developed machine, the specimen was mounted, grinded and then polished using emery paper with frequent application of water to act as coolant while the side pulley disc is rotating. The result obtained from the developed laboratory grinding/polishing machine showed a metallic specimen that was well grinded and well-polished to mirror-like form for further metallographic examination. Based on the efficiency of this developed machine, we therefore recommend this research work for the end users and the metallography industry for metallographic purpose.

Keywords: Development, Laboratory, Metallographic, Grinding/Polishing, Evaluation and Machine.

INTRODUCTION

One of the most useful pieces of equipment for the grinding and polishing metallic materials in order to determine their physical structure using microscopy is metallographic specimen polishing machine. Due to the very small depth of field obtained from an optical microscope, it is essential that the surface is flat; in fact, it needs to be optically flat, acting as a perfect mirror. The specimen therefore has to be polished. This is done using rotating wheels covered with a cloth impregnated with a very fine abrasive compound. The common compounds used are diamond and alumina [16].

Most laboratory grinding machines being used are imported and expensive yet, they do breakdown frequently due to power supply and weak capacity of their electric motor even though they have in-built transformer and they also make noise during operation thereby causing noise pollution. Thus, the need to develop a laboratory grinding machine locally with an electric motor that will not require any transformer and yet, deliver efficiently irrespective of the power situation, will both withstand environmental impact and users friendly, and will also be noise pollution free.

This grinding machine will be produced using our indigenous technology, design and locally sourced materials. Students and investors (machine builders) can later on produce similar ones on their own. This will create job opportunity, save our foreign earns, contribute to and improve the technological development of our dear nation. The entrepreneurial programme and local content initiative of this government will be achieved.

This research work centered on the development of a laboratory grinding machine using locally sourced materials and our indigenous technology will help in polishing metals for metallographic examinations and production of a flat, smooth and mirror-like surface of any metallic materials in order to determine their physical structure using microscopy. This will also reduce over dependence on developed countries in the procurement of laboratory grinding / polishing machine at expensive cost.

The study assists in developing a laboratory grinding machine from our indigenous technology and design using locally sourced materials to achieve a cheap but highly efficient grinding machine with longer service life compared to imported ones.

Various relevant works done by past researchers were reviewed to know the stage they have gone. It was found that little or no work had been done on this project. This is justified by the huge numbered of these machines that were daily imported by various research institutes, universities and polytechnics in Nigeria to this country.

To utilize locally available materials and our indigenous technology to develop laboratory grinding/polishing machine that will be useful for engineering and science research applications/fields. It entails sketching the new design of metallographic specimen grinding / polishing machine (consist of 4 designs); evaluate the design and come out with new design (final design); using the solid work software, make the isometric, orthographic and 3-D drawing.

RESEARCH METHODOLOGY

Materials and Equipment

The following materials were used for this research:

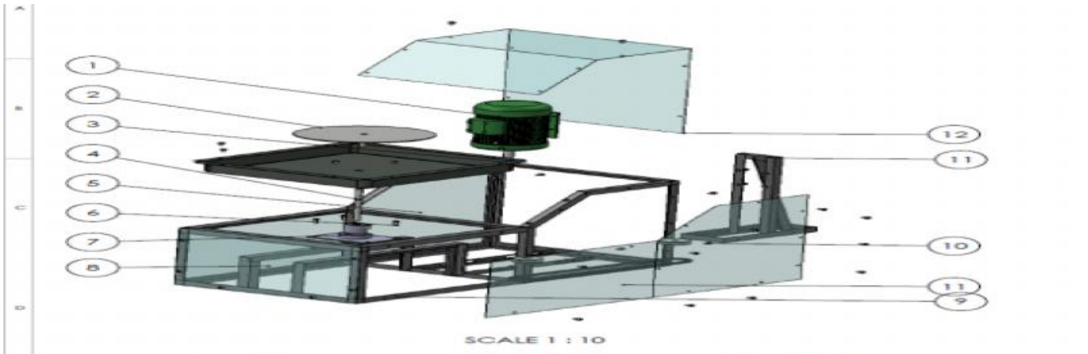
Angle bars, mild steel, electric motor, side pulley disc, galvanized sheet, speed control, pulley, belt, shaft and coupling.

These are some of the equipment used for this study: screw driver; spanner; marking out tools; hacksaw; lathe machine; drilling machine; grinding machine; disc cutter machine; arc welding machine; and bending machine methods.

Design concept

To develop a laboratory grinding/polishing machine using the following components; angle-bars, mild steel plate, electric motor (1 HP), shaft (25 mm), belt, pulley, coupling, side pulley disc (250 mm).

The laboratory grinding/polishing machine body is made of angle bar. The machine consists of a side pulley disc made of mild steel which is drilled at the center where the pulley is connected beneath it with the aid of a shaft. The machine also consists of an electric motor of 1 HP with a pulley under it; and it is positioned vertically so that it will be directly opposite the rotating disc. A-belt (A-40) is used to connect the pulley under the rotating disc to the pulley under the electric motor so that when the machine is plugged to a power source, the speed from the electric motor will cause the disc to rotate. The machine is covered with galvanized steel sheet to prevent corrosion as shown in Fig.1.



PART LISTS			PART LISTS		
ITEM	QTY.	DESCRIPTION	ITEM	QTY.	DESCRIPTION
12	01	GALVANIZED SHEET	6	04	BEARING SUPPORT BOLTS
11	02	ELECTRIC MOTOR SUPPORT	5	01	BEARING
10	02	GAVALNIZED SHEET (X2)	4	01	SHAFT
9	01	MACHINE FRAME	3	01	SHAFT KEY HOLE
8	03	GAVALNIZED SHEET (X3)	2	01	ABRASSIVE GRINDING DISC
7	01	BEARING SUPPORT	1	01	ELECTRIC MOTOR

Fig. 1: Exploded View of the Developed Laboratory Grinding/Polishing Machine

Assumptions

The following assumptions were made for the study: the angle bar is made of mild steel; the diameter of the side pulley disc is taken to be 25 cm; the power of the electric motor to be used is 1 HP; an angle belt is used; the thickness of the shaft is taken to be 25 mm; and galvanized steel sheet will be used to cover the body of the machine.

Design Calculations

Technical parameters: Polishing pad diameter: 250 mm (Single disk); Rotation rate: 1400 rev/min; and Motor: IP44BINS.CR; 1 HP; 0.75 KW, 220 V, 50 HZ

Design Analysis of the Belt Drive

The belt was employed to transmit power from one shaft to another where it is not necessary to maintain an exact speed ratio between the two shafts. There are a lot of belts to transmit power but for this design A-Belt (angle-belt) will be used because it can be used where two pulleys are very near to each other.

Determination of the Speed of the Polisher

$$\frac{N1}{N2} = \frac{D2}{D1} \quad [4] \qquad (1)$$

Where:

$N1 =$ Speed of the motor in revolution per minute $(rev/mins)$

$N2 =$ Speed of the polisher in revolution per minute $(rev/mins)$

$D1 =$ Diameter of the motor pulley in millimeter (mm)

$D2 =$ Diameter of the polisher pulley in millimeter (mm)

Data:

$N1 = 1500\ rev/mins$

$N2 = ?$

$D1 = 80\ mm$

$D2 = 60\ mm$

Using equation 1

$$\frac{N1}{N2} = \frac{D2}{D1}$$

$$\frac{1500}{N2} = \frac{60}{80}$$

$60 \times N2 = 1500 \times 80$

$60 \times N2 = 1500 \times 80$

Making $N2$ the subject of the formula

$$N2 = \frac{1500 \times 80}{60}$$

$N2 = 2000\ rev/mins$ (2)

Therefore, the maximum speed for polisher $N2$ is $2000\ rev/mins$

Tension in the Belt

T_1 is the tension in the tight side of the belt in Newton (N)

T_2 is the tension in the slack side of the belt in Newton (N)

As shown in Fig.2.

Fig. 2: Belt Attached to the Pulleys

$2.3\log(\frac{T_1}{T_2}) = \mu.\theta.cosec\beta$ [4] (3)

$\theta = 180° - 2\alpha$ [4] (4)

$sin\alpha = \frac{R-r}{c}$ [4] (5)

Where:

μ is the coefficient of friction between belt and pulley

θ is the angle of contact on the motor pulley in radian (rad)

β is the groove angle of the pulley in degree (°)

α is the coefficient of increase of the belt length per unit force in degree (°)

R is the radius of the motor pulley in millimeter (mm)

r is the radius of the polisher pulley in millimeter (mm)

c is the centre distance between the two pulleys

Centrifugal tension, TC: This is the force which tends to cause the belt to leave the pulley and reduces the power that may be transmitted. The speed of the A-belt must be 5 to 50 m/s.

Maximum tension, T: This is highest tensional force that can be acted on the belt according to the (Khurmi and Gupta, 2004) Erinle, *et al*. 2011.

$TC = mV^2$ (6)

$T = \sigma A$ (7)

$T_1 = T - TC$ [4,5] (8)

$$V_1 = \frac{\pi N_1 D_1}{60} \quad (9)$$

$$V_2 = \frac{\pi N_1 D_1}{60} \quad (9)$$

$V_1 = V_2 = V$ (10)

$m = \rho x A x L$ (11)

$A = bxt$ (12)

TC is the centrifugal Tension in Newton (N)

T is the maximum Tension in Newton (N)

m is the mass of the belt per meter length in kilogram per meter

V is the belt velocity in meter per second

ρ is the belt density in kilogram per meter cube

A is the cross sectional area in square millimeter (mm^2)

b is the belt width in millimeter (mm)

t is the belt thickness in millimeter (mm)

σ is the allowable stress in Newton per square millimeter (Nmm^{-2})

Determination of maximum tension, T

Data:

$\sigma = \frac{1.7N}{mm2}$ for rubber belt [4] (13)

Assuming:

$b = 15\,mm,$

$t = 10\,mm$

$A = b \times t$
$A = 15 \times 10$

$\boldsymbol{A}$ = 150 $\boldsymbol{n.n.}^2$ (14)

Recall:

$T = \sigma A$ (7)
$T = 1.7 \times 150$

$\boldsymbol{T}$ = 255 $\boldsymbol{N}$ (15)

Determination of mass of the belt, $\boldsymbol{n}$:

Data:

$\rho = 1250\,kgm^3$, Rubber density [1]

$A = 150\,mm^2$
$A = 150 \times 10^{-6} m^2$
$\rho = \frac{m}{v}$ (16)

$m = \rho v$ (17)

$v = Al$ (18)

$m = \rho \times A \times l$ (19)
$m = 1250 \times 150 \times 10^{-6} \times l$
$\boldsymbol{m = 0.1875\ kgm^{-1}}$ (20)

Belt velocity, V:

Data $N2 = 2000\,rev/min,$

The speed should not exceed 2000 rev/min

Recall that: $D2 = 50\,mm$
$D2 = 0.05\,m$
$V = \frac{\pi N1D1}{60}$
$V = \frac{\pi \times 1500 \times 0.08}{60}$
$V = 6.3\,m/s$ (21)

Determination of speed centrifugal tension, Tc:

Data:

$m = 0.1875\,kgm^{-1}$ (From equation 20)

$v = 6.3\,ms^{-1}$ (From equation 21)

$TC = mv^2$ [1,14]

$$TC = 0.1875 \times 6.3^2$$

$$\boldsymbol{TC = 7.44\,N} \quad (22)$$

Determination of tension in the tight side, T1:

Data:

$T = 255\,N$ (From equation 15)

$TC = 7.44\,N$ (From equation 22)

$$T1 = T - TC \quad (8)$$

$$T1 = 255\,N - 7.44\,N$$

$$\boldsymbol{T1 = 247.56\,N} \quad (23)$$

Determination of Coefficient of increase of the Belt Length per unit Force, $\boldsymbol{\alpha}$:

Data:

$$R = \frac{D1}{2}$$

Where:

$$D1 = 80\ mm$$

$$R = \frac{80}{2}$$

$$\boldsymbol{R = 40\ mm} \quad (24)$$

$$r = \frac{D2}{2}$$

Where:

$$D2 = 60\ mm$$

$$r = \frac{60}{2}$$

$$\boldsymbol{r = 30\ mm} \quad (25)$$

Taken:

$$C = 300\ mm$$

Recall:

$$sin\alpha = \frac{R - r}{c}$$

$$sin\alpha = \frac{40 - 30}{300}$$

$$sin\alpha = 0.0333$$

$$\alpha = \sin^{-1} 0.0333$$

$$\boldsymbol{\alpha = 2^\circ} \quad (26)$$

Determination of angle of contact, $\boldsymbol{\theta}$:

Data:

Recall that: $\alpha = 2°$

$$\theta = 180° - 2a \qquad (27)$$

$$\theta = 180° - (2 \times 2°)$$

$$\theta = 180° - 4°$$

$$\theta = 176° \qquad (28)$$

$$\theta = \frac{176° \times \pi}{180°}$$

$$\boldsymbol{\theta = 3rad} \qquad (29)$$

Determination of tension in the slack side, T2:

Data:

$T1 = 247.56N$ (From equation 23)

$\mu = 0.3,$ for rubber material [5,4]

$\theta = 3rad$ (From equation 29)

$2\beta = 30°,$ groove angle of the pulley

$\beta = 15°$

$$2.3 \log \frac{T1}{T2} = \mu\theta cosec\beta \qquad (3)$$

$$2.3 \log \frac{T1}{T2} = 0.3 \times 3 \times cosec15$$

$$2.3 \log \frac{T1}{T2} = 3.4773$$

$$\log \frac{T1}{T2} = \frac{3.4773}{2.3}$$

$$\log \frac{T1}{T2} = 1.5119$$

$$\frac{T1}{T2} = 10^{1.5119}$$

$$\frac{T1}{T2} = 32.5\ N$$

$$T2 = \frac{T\ 1}{32.5}$$

Where $T1 = 247.56$

$$T2 = \frac{247.56\ \boldsymbol{N}}{32.5}$$

$$\boldsymbol{T2 = 7.6\ N} \qquad (30)$$

Design analysis of the power transmitted per belt:

According to the [5,4]:

$$\boldsymbol{P = (T1 - T2)V} \qquad (31)$$

$P =$ Power transmitted in watt (W)

$T1$ = Tension in the tight side of the belt (N)

$T2$ = Tension in the slack side of the belt (N)

V = Belt velocity m/s^1

Determination of power transmitted, $\boldsymbol{P}$:

Data:

$T1 = 247.56\ N$ (From equation 23)

$T2 = 7.6\ N$ (From equation 30)

$V = 6.3\ ms^{-1}$ (From equation 21)

$$P = (T1 - T2)V$$

$$P = (247.56 - 7.6)6.3$$

$$\boldsymbol{P = 1512\ W} \qquad (32)$$

Design analysis of the length of the belt, $\boldsymbol{L}$:

$$\boldsymbol{L = \pi(R - r) + 2C + \frac{(R-r)^2}{C}} \qquad [4] \qquad (33)$$

Determination of the length of the belt, $\boldsymbol{L}$:

Data:

$$R = 40\ mm$$
$$r = 30\ mm$$
$$C = 300\ mm$$

$$L = \pi(R - r) + 2C + \frac{(R-r)^2}{C} \qquad (33)$$

$$L = \pi(40 + 30) + (2 \times 300) + \frac{(40-30)^2}{300}$$

$$L = 70\pi + 600 + \frac{10^2}{300}$$

$$L = (70 \times 3.142) + 600 + 0.3333$$

$$\boldsymbol{L = 820\ mm} \qquad (34)$$

Design Analysis of the Shaft

Assumptions:

Fatigue and shock are considered

The belt on the pulley is at angle 45°

Design of shaft of ductile material based on strength is controlled by the maximum shear theory [14]. The maximum permissible shear stress for the mild steel ductile material is 42 N/mm^2 with allowance for keyway [5]. Hence, the shaft of this polishing machine is only subjected to twisting moment or torque due to torsional loads because the belt drive employs to transmit power [4]:.

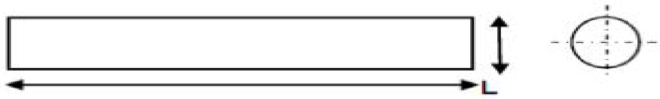


Fig. 3: Shaft of Ductile Material under Torsional Load

In Fig.3 For the belt drive, the torque, T:

$\boldsymbol{T} = (\boldsymbol{T_1} - \boldsymbol{T_2})\boldsymbol{R}$ [5,4] (35)

:T_1 is the tension in the tight side of the belt

T_2 is the tension in the slack side of the belt

R is the radius of the motor pulley

T is the twisting moment or torque pulley in Newton-meter (Nm)

Determination of the torque, $\boldsymbol{T}$

Data:

$T_1 = 245\ N$ (From equation 23)

$T_2 = 7.5\ N$ (From equation 30)

$$R = \frac{D_1}{2}$$

$$R = \frac{100}{2}$$

$\boldsymbol{R} = 50\ \boldsymbol{mm}$ (36)

$$T = (T_1 - T_2)R$$
$$T = (245 - 7.5)50$$

$\boldsymbol{T}$ = 11875 $\boldsymbol{Nn}$ (37)

Torsion Equation according to the [5,4]:

$\frac{T}{J} = \frac{\tau}{r}$ (38)

T is the twisting moment or torque pulley

J is the polar moment of inertia of the shaft about the axis of rotation in millimeter square (mm^2)

τ is the torsional shear stress in Newton per millimeter square (Nmm^{-2})

r is the distance from neutral axis to the outermost fibre

$$r = \frac{d}{2}$$

Where:

d is the diameter of the shaft in millimeter (mm)

Determination of the shaft diameter, $\boldsymbol{d}$

Data:

$T = 11875\,N$ (From equation 30)

$$\tau = 42\ Nmm^{-2}$$
$$r = \frac{d}{2}$$
$$J = \frac{\pi d^4}{32} mm^4$$
$$\frac{T}{J} = \frac{\tau}{r}$$
$$T = \frac{\pi \times 42 \times d^3}{16}$$
$$11875 = \frac{\pi \times 42 \times d^3}{16}$$
$$42\pi d^3 = 11875 \times 16$$
$$d^3 = \frac{190000}{42\pi}$$
$$d^3 = 1440$$
$$d = \sqrt[3]{1440}$$

$$\boldsymbol{d} = 11\ \boldsymbol{mm} \qquad (39)$$

The polisher shaft diameter will be at least twice of the motor shaft diameter for efficient of the machine.

Design analysis of the key:

Key is a piece of mild steel inserted between shaft and hub or boss of the together in order to prevent relative motion between them. It is inserted parallel to the axis of the shaft. Key is subjected to considerable crushing and shearing stresses. Keyway is a slot in a shaft and hub of the pulley to accommodate a key [5,4].

Assumption:

If the exact position of the acting force is not known, so it is convenient to assume that it acts tangentially to the shaft. This force produces both shear and compressive stresses in the key [14].

Shear stress = Force/Area (Nmm^{-2}) [5,10]:

$$\boldsymbol{\tau} = \frac{F}{A} \qquad (40)$$

$$\boldsymbol{F} = \boldsymbol{\tau} \times \boldsymbol{A} \qquad (41)$$

Cross sectional area = length × width (mm^2)

$$A = l \times b$$

Torque = Force × radius (Nm)

$\boldsymbol{T} = \boldsymbol{F} \times \boldsymbol{r}$ (42)

$\boldsymbol{T} = \boldsymbol{\tau} \times \boldsymbol{r} \times \boldsymbol{A}$ (43)

Where $A = l \times b$

$\boldsymbol{T} = \boldsymbol{\tau} \times \boldsymbol{r} \times \boldsymbol{l} \times \boldsymbol{b}$ (44)

Determination of the torque for motor shaft, $\boldsymbol{T}$:

Data:

$\tau = 42Nmm^{-2}$

$d = 10.51mm$ (From equation 39)

$$\frac{T}{J} = \frac{\tau}{r}$$

$$T = \frac{\pi \times 42 \times d^3}{16}$$

$$T = \frac{\pi \times 42 \times 10.51^3}{16}$$

$\boldsymbol{T} = \mathbf{9574}\boldsymbol{Nm}$ (45)

Determination of the length of the key for motor shaft, $\boldsymbol{l}$:

Data:

$T = 9574Nm$ (From equation 45)

For 22 mm diameter shaft, the width of the key, $b = 4.5mm$ and the thickness, $t = 4.5\ mm$ [5,4]

$$r = \frac{10.51}{2}$$

$$r = 5.255mm$$

$$T = \tau \times r \times l \times b$$

$$9598 = 42 \times 5.255 \times l \times 4.5$$

$$l = \frac{9598}{42 \times 5.255 \times 4.5}$$

$\boldsymbol{l} = \mathbf{9.66}\,\boldsymbol{n}$ (46)

Determination of the torque for polisher shaft, $\boldsymbol{T}$:

Data:

$T = 42Nmm^{-2}$

$d = 21mm$

$$\frac{T}{J} = \frac{\tau}{r}$$

$$T = \frac{\pi \times \tau \times d^3}{16}$$

$$T = \frac{\pi \times 42 \times 21^3}{16}$$

$$\boldsymbol{T = 76372Nm} \qquad (47)$$

Determination of the length of the key for polisher shaft, $\boldsymbol{l}$:

Data:

$T = 76372Nm$ (From equation 47)

For 22 mm diameter shaft, the width of the key, b is 16 mm and the thickness, t is 14 mm according to the [5,4].

$$r = \frac{21}{2}$$

$$r = 10.51mm$$

$$T = \tau \times r \times l \times b$$

$$76372 = 42 \times 10.51 \times l \times 16$$

$$l = \frac{76372}{42 \times 10.51 \times 16}$$

$$\boldsymbol{l = 10.81\ mm} \qquad (48)$$

From the above design calculations, the following parameters are obtained:

(a) The size of the pulley is 50 mm radius;

(b) The size of the belt is 820 mm length;

(c) The size of the shaft is 11 mm;

(d) The size of the electric motor is 1 HP; 0.75 KW, 220 V, 50 HZ

Assembling

The assemblies of each component of the grinding/polishing machine as shown in Figs. 4 to 9

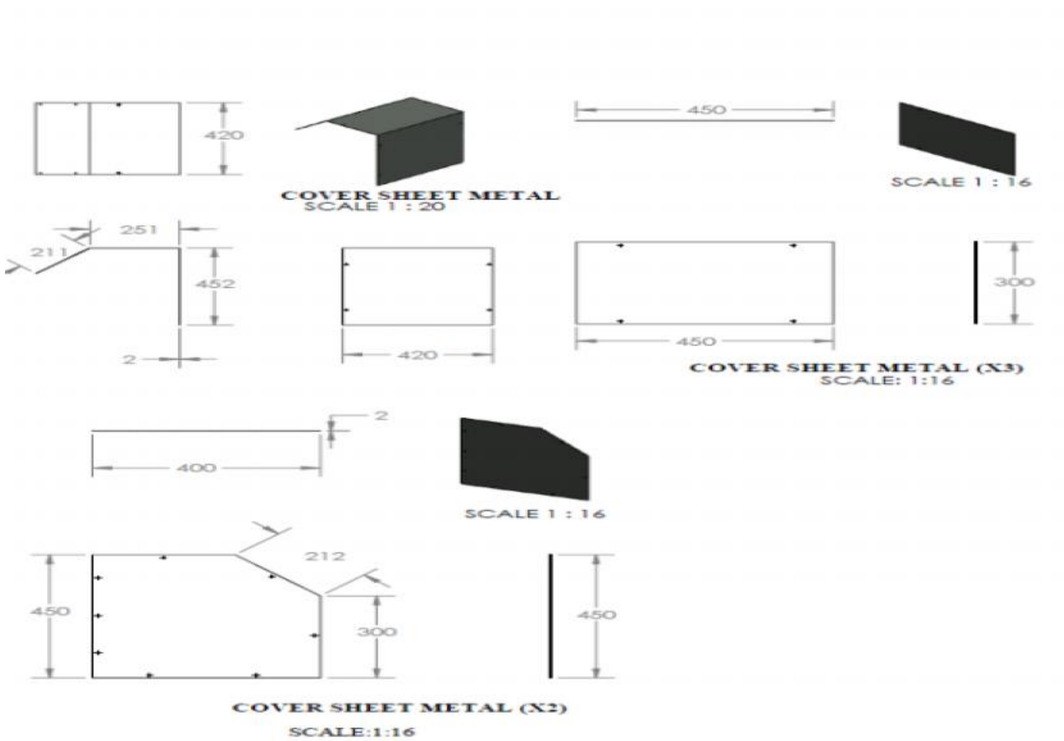


Fig. 4: Different Machine Components of the Laboratory Grinding/Polishing machine

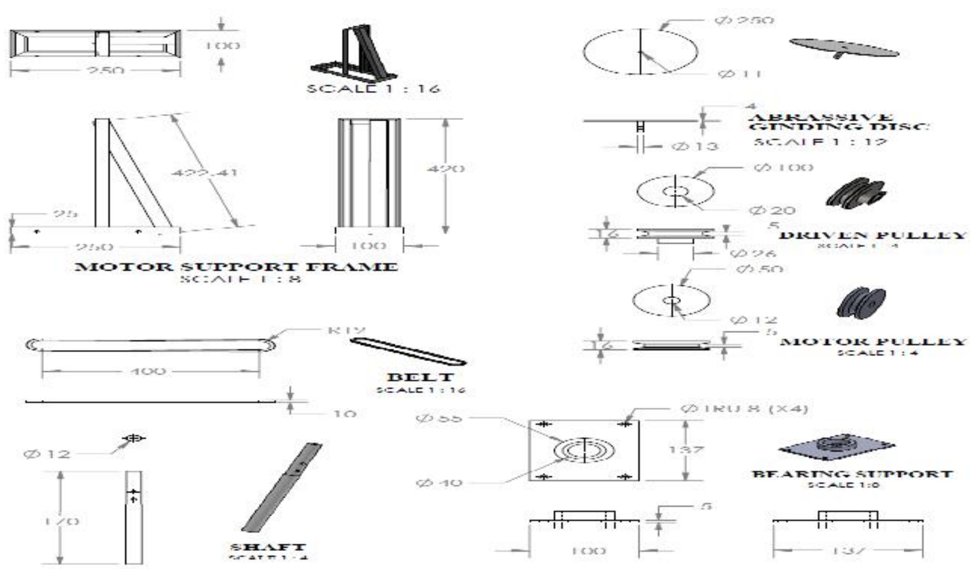


Fig. 5: Different Machine Components of the Laboratory Grinding/Polishing machine

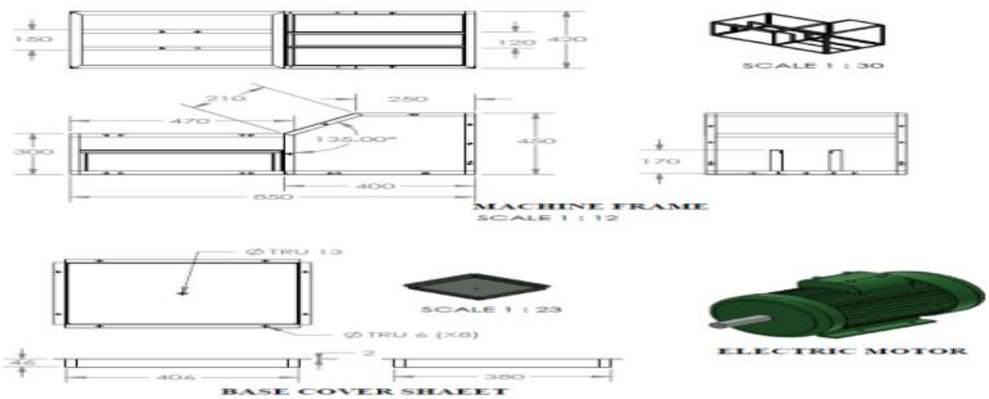


Fig. 6: Different Machine Components of the Laboratory Grinding/Polishing Machine

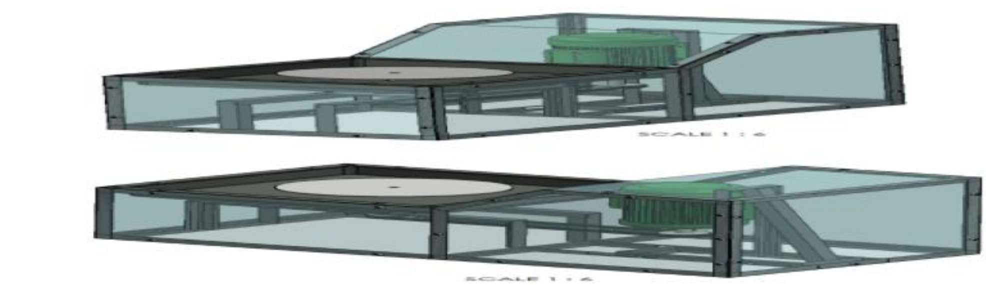


Fig. 7: Isometric View of the Laboratory Grinding/Polishing Machine

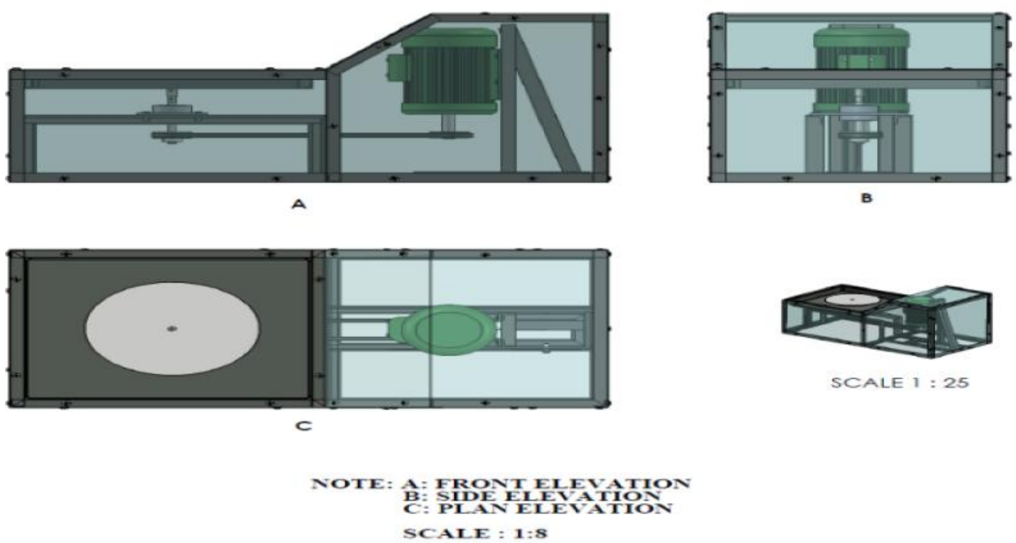


Fig. 8: Orthographic View of the Laboratory Grinding Machine

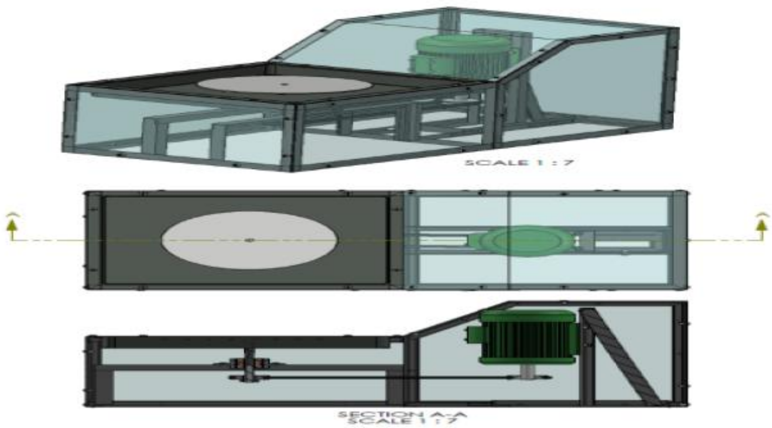


Fig. 9: Sectional View of the Laboratory Grinding/Polishing machine

Cost estimate

The estimated costs of actualizing this research work are as shown in Table 1

Table 1: Cost Estimate of the Developed Laboratory Grinding / Machine

S / N	ACTIVITIES	AMOUNT (#)
1	Design and 3-dimensional AutoCAD drawing with dimension	50,000
2	Materials Sourcing	50,000
3	Fabrication	25,000
4	Transportation & Miscellaneous	5,000
	TOTAL	130,000

RESULT

The result obtained from the operation of the developed laboratory grinding/polishing machine shows the following: The design was perfectly done. The fabrication of the machine is properly done with consideration to rigidity; the testing result produced a metallic specimen that was well grinded and well-polished to a mirror-like form for further metallographic examination. The specimen was mounted, grinded and then polished using emery paper with frequent application of water to act as coolant while the side pulley disc is rotating at 2800 rev / mins.

COST COMPARISM

Comparing this research work with the available ones (imported) in the market in terms of cost, we realize that the imported ones are more expensive than the locally produced grinding/polishing machine. The market survey carried out shows that the cost price of the imported ones excluding VAT and freight ranges from $3000- $110000 (N615,000- N22.55million) at the prevailing exchange rate of $1 to N205 while the cost of producing our own developed laboratory grinding / polishing machine is # 130,000

PERFORMANCE EVALUATION

The ability of the machine to perform effectively determines the overall success of the project for high performance level. The machine is expected to grind/polish metal specimen to produce smooth, flat and mirror-like surface within few seconds. This was achieved with relative success with an efficiency of 70 % at the speed of 2800 rev/min during its operation. These results vary as the speed and grinding/polishing method is dependent on the operator.

CONCLUSIONS

The following conclusions were drawn from this study:

The locally made metallographic specimen polishing machine gave good results when compared with the imported machine.

It gave accurate results when used to grind and polish metallic materials during testing and evaluation.

The satisfactory performance of the metallographic specimen polishing machine proved that aim and objective of the project was achieved. During the test, it was discovered that all the level of speeds has important role to play in giving good, smooth and fine grinding and polishing.

The machine has the ability to grind and polish any kind of metals, simple to operate, users friendly and requires minimum maintenance.

RECOMMENDATIONS

The following recommendations were made:

Based on the efficiency of this machine, we recommend this research work for the end users of metallographic purpose such as Research institutes like Engineering Materials Development Institute, Akure, FIIRO Lagos, PRODA Enugu, PEDI Ilesha, NMDC Jos.etc. Other end users are Nigerian Universities and Polytechnics running programmes such as Geology, Mineral Processing, Mining Engineering, Physics with Materials/Electronics, Chemistry, Mechanical/ Production Engineering and Metallurgical and Materials Engineering.

Finally, the technology behind the production of the laboratory grinding/polishing machine is relatively easy and users-friendly; we therefore advise commercial production of this machine by various parastatals such as NAESENI, NBTI, FIIRO, PTDF and Raw Materials Research and Development Council by partner with us to achieve this goal. This will help exploit our indigenous technology and design to contribute to the technology advancement goal of our dear nation NIGERIA.

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