Scientia Africana, Vol. 17 (No. 2), December 2018. Pp 69-79
 ISSN 1118 – 1931

DESIGN AND DEVELOPMENT OF MULTIPLE DRILLING SIZES MACHINE

[1] M. O. Eruotor and M. O. Atenaga [2]

[1]Department of Physics with Electronics, Western Delta University, Oghara
[2]Department of Physics with Electronics, Western Delta University, Oghara
[1]Email: meruotor@yahoo.com Phone: 07034669324
[2]Email: michaelatenaga@hotmail.co.uk Phone: 08077688274, 08132777696

Received:11-04-18
Accepted:12-04-18

ABSTRACT

Now a day, machines are widely controlled by embedded system. To meet the need of exploding machines is necessary. Our project even is rotated to easily drill at any direction. So that job setting operation is not complicated as well as reduces the setting time for the operation. It also takes into consideration the most effective method of controlling the drilling machine by manually. Materials like wood, plastic and light metals can be drilled with this. The work piece is fixed on the work table, which is provided with a moving arrangement. The drilling machine is one of the most important machine tools in a workshop. In a drilling, machine holes may be drilled quickly and at a low cost. The holes is generated by the rotating edge of a cutting tool known as the drill, which exerts large force on the work clamped on the table. As the machine tool exerts vertical pressure to original a hole it loosely called a "drill press". Drilling is the operation of producing circular hole in the work – piece by using a rotating cutter called drill, the most common types of drill is the twist drill. The machine tool used for drilling is called machine. The drilling operation can also be accomplished in a lathe, in which the drill is held rotated by a chuck. This multiple drill sizes is performed for different angle drilling in the working job. Indexing plate and up/down mechanism is available in this multiple drilling sizes machine.

Key words: drilling machine, lead screw, supporting frame, guide ways, electric gear motor, spur gear, drill vice, bevel gear, drill chuck with drift key, drill bit.

Nomenclature

S_c = Compressive stress, E_c = Compressing strain, k = slenderness ratio, F = Crushing load, I_{cr} = Crippling stress, F_u = Ultimate load columns, L = bending stress, n_{me} = efficiency of the electric motor, P_i = power input of motor, P_2 = Power output of motor, T = Torque, T_g = Braking torque, V = Velocity ratio, V_{tb} = Velocity ratio for thickness of belt, V_1 = Velocity ratio of belt drives, W = workdone, P = power transmitted, F_D = Drilling force, RT = Reuleaux Triangle, D = Depth of cut, MRR = Material Removal Rate, t = Machinery time

Units of the Quantities

QUANTITIES	UNITS
Compressive stress (SC)	N/mm^2
Compressive strain (Ec)	N/m
Slenderness Ratio (k)	M
Crippling Stress (Icr)	N/m^2
Ultimate Load Columns (Fu)	N/mm^2
Bending Stress (L)	N/m
Efficiency of Electric Motor (N_{me})	%
Power Input of Motor (P_1)	Volts
Power Output of Motor (P_2)	Watts
Torque (T)	N/mm
Braking Torque (Tg)	N
Velocity Ratio (V)	m/s
Velocity Ratio for Thickness of Belt (V_{tb})	Joule
Velocity Ratio of belt drives (V_1)	Joule
Workdone (W)	N m/s
Peripheral Velocity of the Belt (V_2)	m/s
Power Transmitted (P)	Nm/s
Drilling Force (FD)	N
Reuleaux Triangular (RT)	m^3
Depth of Cut (d)	mm
Material Removal Rate (MRR)	mm^3/min
Machining Time (t)	Min
Feed Rate (f)	mm/min
Diameter of the Drill (D)	mm
Speed of Rotating (N)	rpm
Screw Spindle (dc)	mm
Nominal Diameter of Screw (do)	mm

INTRODUCTION

Drilling machine is one of the most important machine tools in workshop. It was designed to produce a cylindrical hole of required diameter and depth on metal work pieces. Though holes can be made by different machine tools in a shop, drilling machine is designed specifically to perform the operation of drilling and similar operations drilling can be done easily at a low cost in a shorter period of time in a drilling machine. Drilling can be described as the operation of producing a cylindrical hole of required diameter and depth by removing metal by the rotating edges of a drill. The cutting tool is known as drill fitted into the spindle of the drilling machine. A mark of indentation is made at the required location with a centre punch. The rotating drill is pressed at the location and is fed into the work. The hole can be made upto a required depth.

A. Drilling Machine Construction

The basic parts of a drilling machine are a base, column, drill head and spindle. The

Scientia Africana, Vol. 17 (No. 2), December 2018. Pp 69-79
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base made of cast iron may rest on a bench, pedestal or floor depending upon the design. Larger and heavy durty machines are grounded on the floor. The column is mounted verticaly upon the base. The drill spindle, an electric motor and the mechanism meant for driving the spindle at different speeds are mounted on the top of the column. Power is transmitted from the electric motor to the spindle.

B. Drilling Machine Working Principle

The working operation of this multiple drilling sizes machine is initially started from the universal motor through A.C Power Source. In this, there is one power sources, received from the power supply. After that the indexing mechanism is controlled, to fix the desired angle. A lock nut is attached to the indexing plate to avoid and deviation of angle during drilling. According to the requirement of drilling it will tilt very precisely. The rotary motion of the indexing plate is given to the bevel gear. This rotary motion is given the shaft and used to rotate the drill head. The depth of cut will be adjusted by the screw in the dill head structure. The speed of motor is controlled using regulator. After that motor is started the desire angle and desire speed is fixed then drilling process performed. With the help of our project, we can achieve the multiple drill sizes hole very precisely. Thus project can perform very tiny angular hole and variation can be achieved. **[1]**

Drilling machine is to provide rotating motion to Reuleaux Triangle (RT) and tools the drilling machine is used. The end of universal joint is connected to tool holder of drilling machine. The spindle speed is constant for all operations, while the cutting speed varies all along the cutting edge. Cutting speed is normally computed for the outside diameter. This variation in cutting speed along the cutting edges is an important characteristic of drilling.

The centre of reuleaux triangle (RT) must rotate itself and also revolves in a non-circular path, by using universal joint RT can revolve in non-circular path, coupling or joint which can transmit rotary power by a shaft at any selected angle, coupling in a rigid rod that allows the rod to "bend" in any direction, and is commonly used in shafts that transmit rotary motion. It consists of a pair of hinges located close together, oriented at 90^0 to each other, connected by a cross shaft. The universal joint is not a constant-velocity joint. **[2]**

Drilling a hole to required specification in production drilling can be challenging when the work piece material is especially difficult – to – machine. Trends in manufacturing from the largest titanium or composite parts for aerospace to Inconel for the smallest medical devices require versatility in handling the principal enemies of successful drilling, heat, abrasiveness, and hardness or in the case of materials like austenitic stainless, gummy softness. Each poses difficulties that must be overcome through a combination of drill – point geometry and edge prep, subtract, coatings, and coolant delivery. **[3]**

Automation has becomes key to unlock the manufacturing secrets and the way for determining finest possibility of processing operation in the industries, that will lead to achieve high throughput accuracy and repeatability in production. Automation leads to perform almost all associate activities in manufacturing industries. Such as Computer Aided Process Planning and CNC Machining Centre are most popular these days, which can also work handsomely parallel with CAM software. Which overcoming all parameter of manufacturing, automation has provided advance solution for performing nearly all operation like milling, drilling etc… the most advance version – drilling machine is CNC (Computer Numeric Control). The disadvantages of CNC machine, they are expensive and required skilled operator for handling. Today the industrial growth purely depends upon latest machines, therefore, the subject of advance machines is extending too widely.

The paper mainly focuses on the application of industrial automation for small space manufacturing units. As for the small scale industries, drilling operations are most common and repetitiveness of the task can lead to countless frustrations among the labourers particularly the beginners. Further, the time taken to drill a component can have significant effect on the production. For performing drilling operation there are manual drilling machine, which come in many shapes and sizes, from small handheld power drills to bench mounted and finally floormounted model. As well as Automatic Drilling Machines available in market, which follow up, control the CAD ICAM process, and helps to machine the design product as per specification of the production process and financial capacities of the companies. The analysis of information flows shows that there are key gaps between the Computer - Aided Designs (CAD) and manufacturing units, which indicates no solution linked CAD model directly. **[4]**

Increasing the accuracy and productivity are the two basic aims of mass production. As we know the solution to this is by reducing the manual fatigue and also reducing the set up cost of the machine. In this case the device that fulfils our needs is the use of jigs. In such a case the designer tries to draw out every single hole with the help of square, straighteners, scribers and center hole. In order to align the axis of the drill with the axis of the hole we generally go for trial and error method. Accuracy is the main problem in such cases. In doing so accuracy increase the work load on the operator. Hence using jig to position and guide the tool to its right path is preferred rather than using scribers, squares, straighteners or center punch etc. thus, the productivity is increased which is done by eliminating individual marking, positioning and frequent checking. Interchangeability is the chief advantage here. All the parts fit in properly except only the similar components are interchangeable. One does not need to repeatedly unclamp and clamp the object for various purposes like positioning as the locating, guiding and clamping of the tool is done by the jig itself. Bushing is used which is a tool guiding tool. So, it reduces the presence of skilled labourer. Drill jig helps to ream, drill and tap at a much faster speed and with great accuracy as compared to holes done conventionally by hand. The responsibility to maintain the accuracy of the hole is now shifted from the operator and given to the jig. May it be a drill fixture or a drill jig the necessity of a clamping device is inevitable. In case of a drill jig bushings are used. These drill bushings guide the drill bit during the drilling operation. Generally, work piece is held by a fixture and the fixture is arranged in such a way that the loading and unloading of the job is fast as we all know a fixture is a production tool which is mainly used to hold, locate and support the work piece firmly to the table. Feeler and set blocks are

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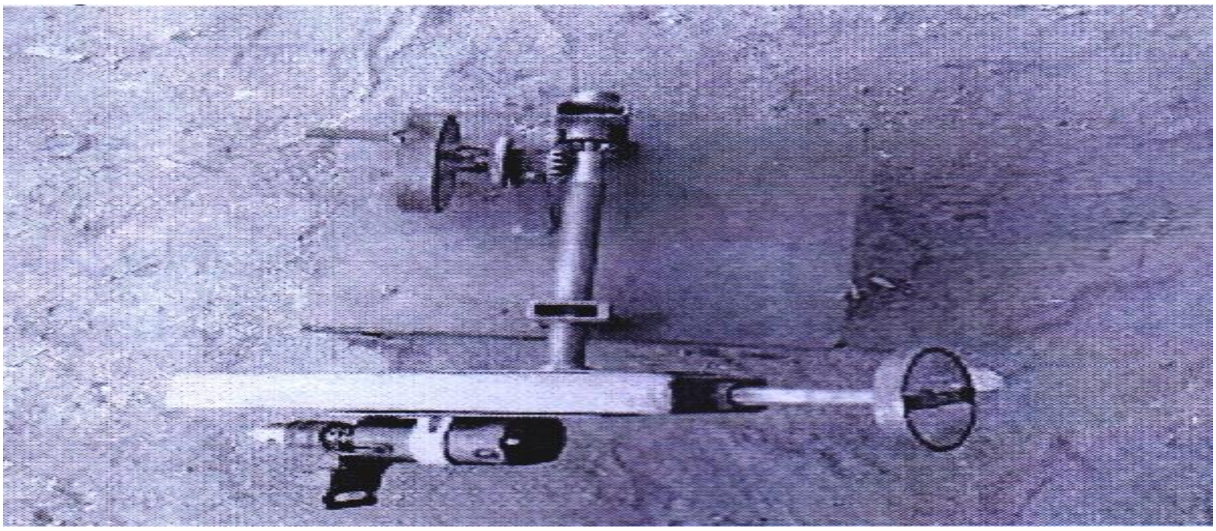
sometimes used to provide reference of the cutter to the work piece. **[5]**

MATERIALS AND METHODS

Our project even rotate easily drills at any direction. So that job setting operation is not complicated as well as reduces the setting time for the operation. It also takes into consideration the most effective method of controlling the drilling machine by machine by manually. Materials like wood, plastic and light metals can be drilled with this. The work piece is fixed on the work table which is provided with a moving arrangement. As the machine tool exerts vertical pressure to original a hole it loosely called a "drill press". This multiple drilling is performed for different angle sizes drilling in the working job, indexing, plate and up/down mechanism is available in this multiple drilling sizes machine



RESULTS

Equation is given as:

$$\frac{M}{T} = \frac{l}{y} = \frac{E}{R} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . . (1)$$

$$L = y \times \frac{E}{R} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \ldots\ldots \quad \ldots \quad (2)$$

Design Constraint

The following are the constraints used in the design method

The Electric Motor

The electromotive force of the electric motor

$E.M.F = V - I_a R_a$(volts)……………… (3)

Power input of the motors (Pi)

$P_1 = I_a V$ (volts)………………………… (4)

Power at the output shaft of the motor (P_2)

$P_2 = \frac{2\theta NT}{60}$ [watts] …………………… (5)

Efficiency of the electric motor

$$Efficiency\ of\ the\ electric\ motor = \frac{power\ output}{power\ input}\ [\%] \ldots\ldots\ldots . . \ldots\ldots\ldots . . (6)$$

The Planetary gear train

Braking torque, $Tg_3 = Tg_1 \left(\frac{wg1}{wg2} - 1\right) = Tg1 \left(\frac{Ng1}{Ng2}\right)$ ………. (7)

$Tg_2 = Tg_3 + Tg_1$ [N] …………………… (8)

Velocity ratio of belt drive

Velocity ratio V = $\frac{N2}{N1} = \frac{d1}{d2}$ … … … … … (9)

Velocity ratio for thickness of belt V+b = $\frac{d1+1}{d2+2}$ … … … … … … … … … … … … … … … ….(10)

Peripheral velocity of the belt (V_2) is given as

$V_2 = \frac{\pi d_2 N_2}{60} \left[\frac{m}{s}\right]$ … … … … … … … … … …... (11)

Power Transmitted by a belt

Workdone per second W = (T_1 – T_2) V (Nm/s)……………………………… (12)

Power transmitted P = (T_1 – T_2) V [Nm/s] …….(13)

Force used in drilling F_D = $\frac{Td}{R}$ [N] ……(14)

Table 1: shows machine components and their functions

S/N	COMPONENTS	FUNCTIONS
1.	The electric motor	Provides the needed torque
2.	The chuck assembly	Transmits the torque from the electric motor to the drill bit
3.	The adjustable clutch	Stop the motor and the chuck from rotating when necessary
4.	Power switch	Allows or stops current flow to the electric motor
5.	The column	Allow up and down movement of the worktable to accommodate work of various sizes on the drilling machine.
6.	The base	It holds the entire machine vertically in place
7.	Power head	It house V belt drive cone, pulleys, shaft, keys, electric motor.

Table 2: show the input parameters used in the design and development of multiple drilling sizes machine

INPUT PARAMETERS	SYMBOL	VALUES	UNITS
Voltage supply	V	12	[V]
Speed range of the motor	Na	0 – 5.50	[rpm]
Maximum chuck diameter	Dm	0.01	[m]
Maximum torque of motor	Tm	15	[N/m]
Diameter of output shaft of the motor	Ds	0.0005	[m]
Number of pairs of poles of motor	P	2	H
Number of armature conductors of the motor	Z	120	H
Flux pair pole	ϕ	0.0023	[Wb]
Number of parallel circuit	C	2	H
Resistance of armature circuit	Ra	0.1	[ohms]
Current of armature circuit	La	17	[amp]
Radius of drill bit	R	0.001	[m]
Yield point of mild	Ftp	310	[N/m^2]
Factor of safety	Fs	2	H

Calculation

Selecting

SAE 1020 as material of lead screw

Syt = 246N/mm^2, E = 250 x 103N/mm^2

Assume FOS = 2, W = 600N

1. Design of screw spindle

By Rankin formulae

Syt = $\frac{Fcr}{A}\left[1 + \frac{[\ ]}{\propto 2}\left(\frac{1}{k}\right)\ \right]$ = 246N/mm^2

For = WXF.O.S = 6.00 x 2 = 1.2 x 10^{3}N

$k = \frac{d\,[\ ]}{[\ ]}$

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$$246 = \frac{[\ ][\ ]\times[\ ]\ [\ ]^2}{\frac{1}{3}\times d[\ ]^2}\left[1 + 1(300/\frac{d[\ ]}{[\ ]})^2 /10.03\times 10^3 \times 0.25\right]$$

dc = 7.93mm

2. Nominal diameter of screw (do)
dc = 0.84d_0
d_0 = $\frac{7.93}{[\ ][\ ][\ ]} = \frac{7.93}{0.84} = 9.44mm = 10mm$

3. Screw terms
(i) Mean diameter (dm)
dm = $d_0 - \frac{p}{[\ ]}$
dm = 24 - $\frac{5}{[\ ]}$ = 21.15mm
(ii) Lead = 2P = 10
$\propto = tan^{-1}\left[\frac{lead}{d[\ ]}\right]$
$= tan^{-1}\left[\frac{[\ ]\times 3}{[\ ]\times[\ ]\ [\ ]5}\right]$
$\propto = 5.07^0$
$\phi = tan^{-1}\left[\frac{N}{sinB}\right]$
$= tan^{-1}\left[\frac{[\ ][\ ][\ ]}{\sin a[\ ]}\right] = 6.84^0$

4. Load on screw thread
(i) Torque,
T = $\left[\frac{Wd[\ ]}{[\ ]}\right]\tan(\propto + \phi)$ =
$\left[\frac{W\times[\ ][\ ]5}{[\ ]}\right]\tan(5.07 + 6.84)$

T = 2.267W, N-mm - - (1)

Torque due to applied force by lever
T = 600×200=120000N-mm T=120×10^3N-mm - - - (2)
Put the value of 'T' in efn (1), we get
120×10^3 = 2.267W

W = $\frac{[\ ][\ ][\ ]\times 10^3}{[\ ][\ ][\ ]7} = 52933.39N$

5. Power required
(i) To engage the load (T_1)
$T_1 = \left[\frac{Wd[\ ]}{[\ ]}\right]\tan(\propto + \phi)$
=
$\left[\frac{5[\ ]933\times[\ ][\ ]^2\times[\ ][\ ]5}{[\ ]}\right]\tan(5.07 + 6.84)$
T_1 = 120017.1049N-mm
= 120.017N-mm
(ii) Torque require to disengage (T_2)
T_2 = $\frac{Wd[\ ]\times N[\ ]}{[\ ]} - \frac{5[\ ]933\times[\ ][\ ]^2\times 7.93\times[\ ][\ ][\ ]}{[\ ]}$
= 25185.52N-mm
T_2 = 25.18552N-m
(iii) Total Torque (T)
T = T1 + T2
= 120.017 + 25.18552
T = 145.2026N-m

6. Power Required
(N=30rpm) Assume for human being
p = $\frac{[\ ]T[\ ]T}{[\ ][\ ]} = \frac{[\ ]T\times[\ ][\ ]\times[\ ][\ ]5.[\ ][\ ][\ ]5}{[\ ][\ ]}$
p = 304.11kw

7. Stresses in lead screw
dc = 7.93mm
d_0 = 10mm
T_{comp}= $\frac{W\times[\ ]\times d[\ ]^2}{T} = \frac{[\ ][\ ][\ ][\ ]\times(7.93)^2}{T} = 12.14N/mm$
T = $\frac{[\ ][\ ][\ ]T}{\pi d[\ ]^2} = \frac{[\ ][\ ]\times[\ ][\ ][\ ]5}{\pi\times(7.93)^2}$
= 16.800N/mm^2

8. Principal Stresses
$T_{max} = -(T_{comp} + \sqrt{T_{comp}} + 4)$
=
$-(12.14 + \sqrt{12.14 + 4(16.800)})$

9. Number of thread in engagement

$$P_b = \frac{[\ ]\,w}{\pi\,(d[\ ]^2 - d[\ ]^2)h}$$

$$P_b = \frac{[\ ] \times 59.933 \times [\ ]\,[\ ]^2}{\pi\,(d[\ ]^2 - d[\ ]^2)h}$$

Take $P_b = 15N/mm^2$
Safe bearing pressure
h = 121.05 = 121 x 3 = 363mm

Table 3: Results

S/N	QUANTITY NAME	DESCRIPTION OF CONVERSION
1	Nominal Diameter of Screw	10mm
2	Mean Diameter	21.5mm
3	Core Diameter	7.93mm

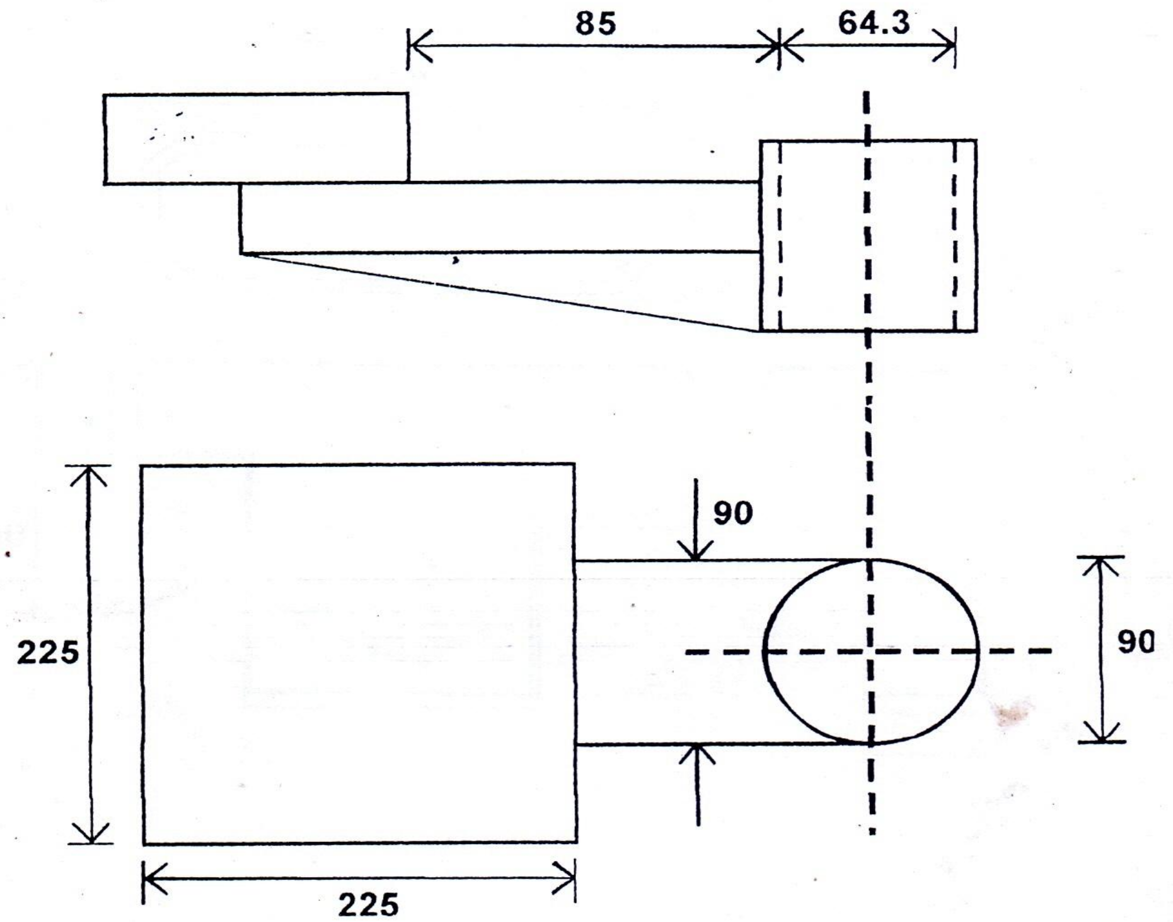

Figure 1. Front Elevation of the machine

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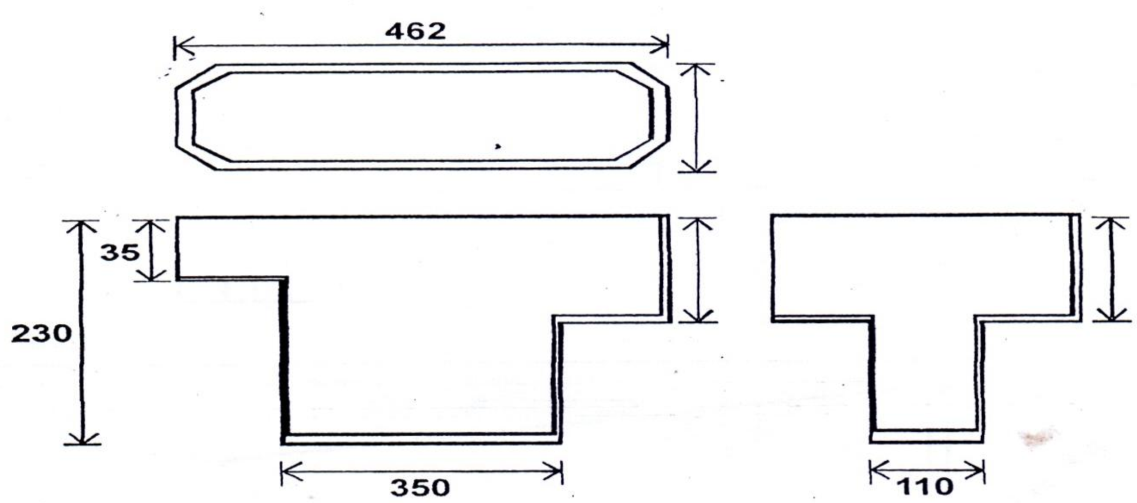


Figure 2. End Elevation of the machine

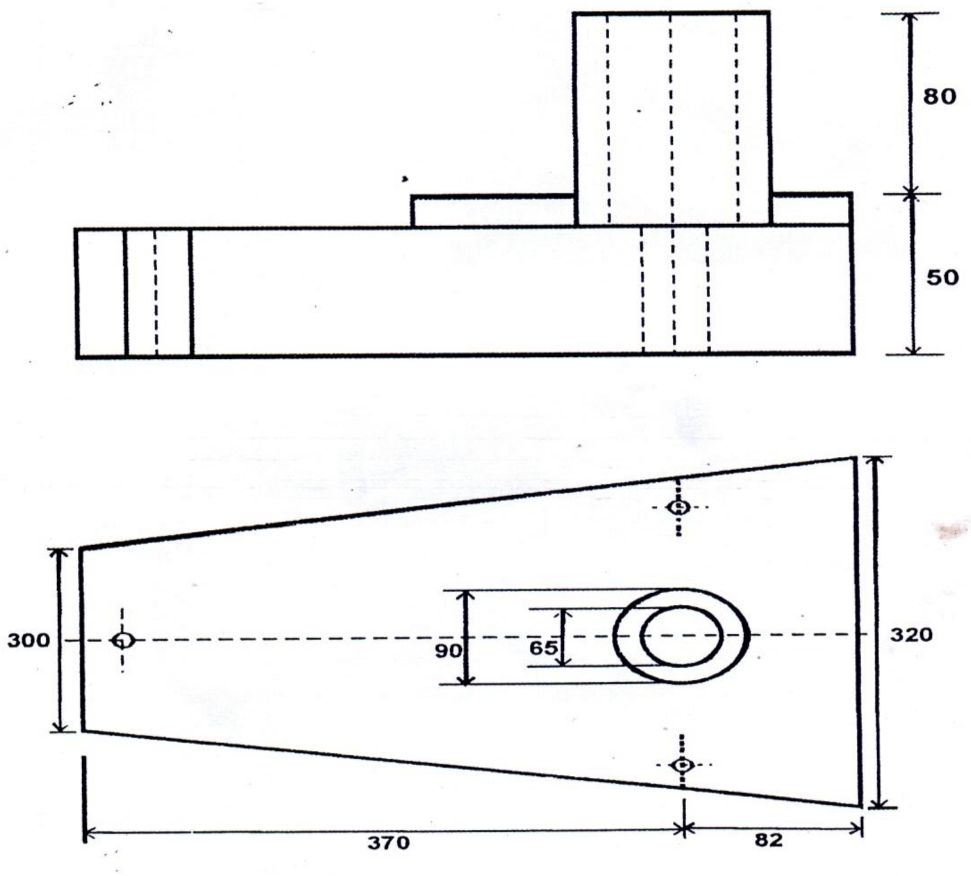
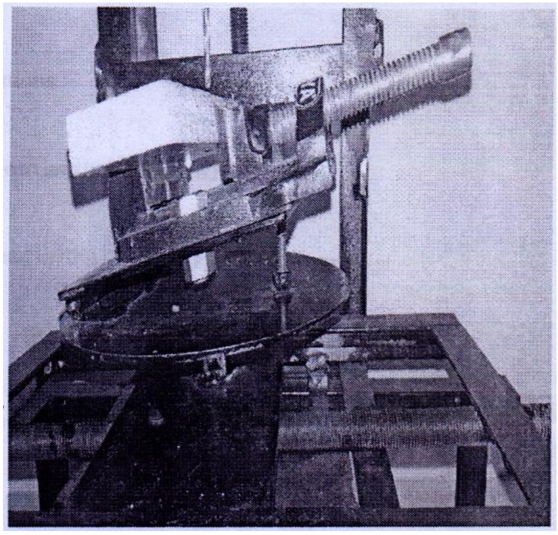
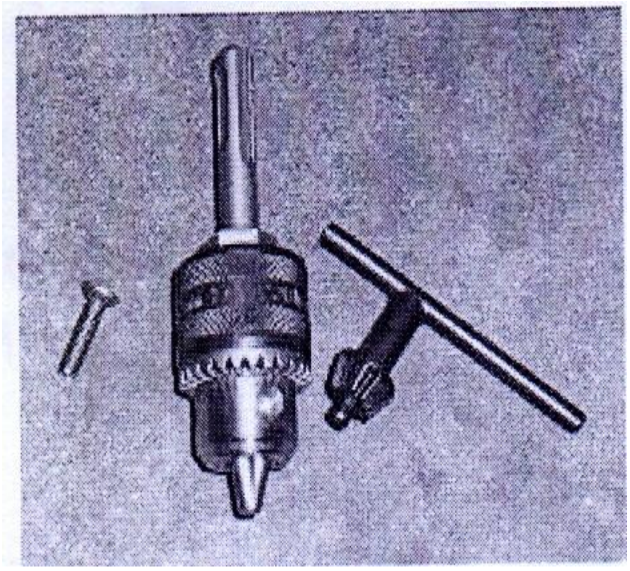


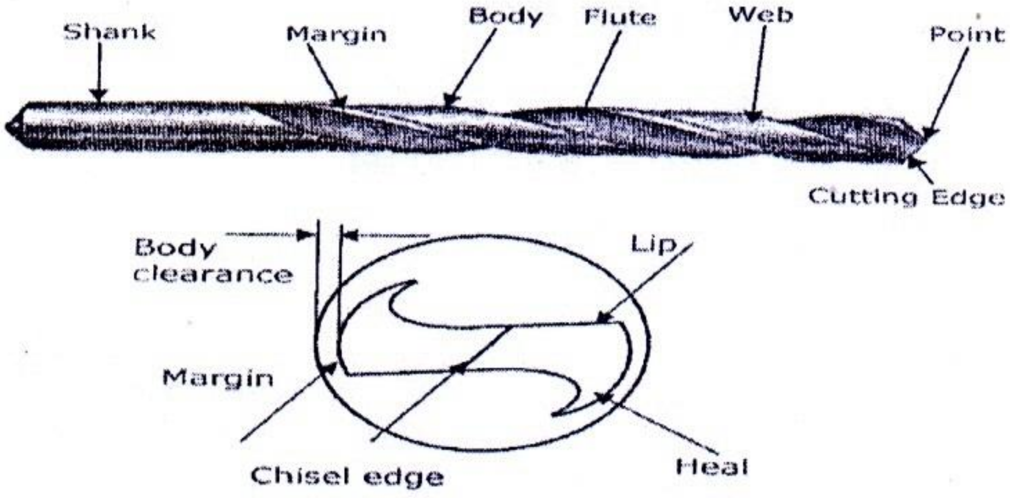
Figure 3: Machine Base



Inclination of fixture



Drill Chuck



Nomenclature of drill tool

Drill bit

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DISCUSSION

Figure 1, 2 and 3 shows the front elevation, end elevation view and the machine base drawing of the multiple drilling sizes machine design and development.

The efficiency of the motor is acceptable. It delivers more than 80% of the power input. This has a positive effect on the whole multiple drilling sizes machine as the torque of the drill but is relatively high and the force of the drill bit is also high. The material used which has a shear stress of 1,200,000,000 Pascal offers a resistance far lower than the force produced by the drill bit. Thus, the drill bit is able to make a hole in the material with a force of 25069.58 newton. For tougher materials the net drilling force reduces significantly. For every hard material, the net drilling force becomes negative, suggesting that drilling cannot occur and damage may occur to the chuck.

The result of the design calculation and the resulting specification for the production of the designed work is shown in table 2 computation of design calculation. The parameter may be varied to set designed specification of design work. Some of the materials used in the development of the multiples drilling sizes machine also shown in Table 1.

The various tests carried out and the results obtained demonstrate that the multiple drilling sizes machine achieved its design and development aims. The system worked according to specification and quite satisfactory. The multiple drilling sizes machine is relatively affordable and reliable. It is easy to operate.

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