

PAPER • OPEN ACCESS

## Evaluation of a constructed manual drilling machine for small scale operation

To cite this article: S.O. Banjo *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1107** 012194

View the [article online](#) for updates and enhancements.

You may also like

- [The influence of the drilling rate of the raise boring machine on the stability of the surrounding rock of a inclined shaft with large dip angle](#)  
LI Yingquan, SONG Zhaoyang and JING Guoye
- [Fabrication and Automation of Drilling Machine by Using Arduino](#)  
Mohammad Nasir Khan, Mohd Shadman Ansari, Md Irfan Ansari et al.
- [Design Improvements in Conventional Drilling Machine to Control Thermal Necrosis during Orthopaedic Surgeries](#)  
R V Dahibhate, S B Jaju and R I Sarode



The Electrochemical Society  
Advancing solid state & electrochemical science & technology

242nd ECS Meeting

Oct 9 – 13, 2022 • Atlanta, GA, US

Abstract submission deadline: **April 8, 2022**

Connect. Engage. Champion. Empower. Accelerate.

**MOVE SCIENCE FORWARD**



Submit your abstract



## Evaluation of a constructed manual drilling machine for small scale operation

S.O. Banjo<sup>1\*</sup>, O.O. Joseph<sup>1</sup>, O.S.I. Fayomi<sup>1</sup>, M. Udor<sup>1</sup>, J.O. Dirisu<sup>1</sup>, D.O. Omole<sup>2</sup>, S.A. Afolalu<sup>1</sup>, I. Osagie<sup>3</sup>

<sup>1</sup>Department of Mechanical Engineering, Covenant University, P.M.B. 1023, Ota, Nigeria

<sup>2</sup>Department of Civil Engineering, Covenant University, P.M.B. 1023, Ota, Nigeria

<sup>3</sup>Nigerian Building and Road Research Institute (NBRRI), Km 10 Idiroko Road, Ota, Ogun State

\*Corresponding author: solomon.banjo@covenantuniversity.edu.ng

### Abstract

In this study, a critical analysis was carried out on the various classes of drilling machine to establish their performance based on their applications and also, to have comparative evaluation between electrically driven drilling machines (EDDM) and manually operated drilling machine (MODM). In the ancient days, flat punch was used to make holes on materials, but due to advancements in technology, drilling machines are now being used instead, making the work easier and faster. There are different drilling machines, including radial, sensitive, upright, gang, deep hole, multiple spindles, and automated drilling machines. Also, an indigenous table-mounted manual drilling machine was fabricated, with a rigid and robust structure but flexible to operate enhances the production of the hole on solid materials such as metal, wood, Teflon, and other materials. This evaluation has provided an enormous privilege for the manual operated drilling machine to be employed for small scale operation (SSO) and to serve as a relief to the less privilege communities. More so, this simple method would save the end-user from the unnecessary expense on fuel and expensive bills.

Keywords: MODM, rigid structure, EDDM, small scale operation

### 1. Introduction

The process of using drilling machines as a tool for producing holes on solid materials has been a worldwide phenomenon, particularly in the Engineering and Non-engineering based industries where drilling holes are daily. The drilling machine became active with the help of drill bit, which serves as the cutting edge, and it often fixed to the chuck of the device, and likewise, drill bits are varied in sizes depending on the size of the hole drilled. The first electrical drilling machine was invented in 1889 by Arthar Amott and William Blench [1]. There are diverse operations carried out on the drilling machine, including drilling, boring, countersinking, reaming, spot facing, counterboring, and each of the processes has different specific tools [2]. The drilling machine's construction required wear and tear resistant materials because of the work to be carried out. Hence the choice of material selection in fabricating the manual drilling machine cannot be overemphasized. The device has to be solid and rigid to withstand any form of distortion. The material used in the development of the parts were alloy steels, high-speed steel, high tensile steel, which satisfied to have excellent properties [3]. Steels are solid material with improved hardness, especially at high temperature, to increase the tensile strength and resistance to fatigue and wear [4].

The machine consists of a column on which other parts are fixed directly to a worktable. The device is flexible and compact, it has a wheel that can be turned by hand to cause the turning effect of the spindle on which chuck was attached, and it is designed in a replica of radial type, which sorely depends on electricity [5]. The kind of drill bit to be fixed into the chuck depends on the diameter of the hole required, and the cutting speed depends on how fast the



machine wheel can revolve. The feeding system is controlled by turning a small wheel fixed directly on the spindle top in either clock wisely for feeding the tool or anticlockwise to withdraw the tool from the workpiece. The size of the workpiece is not an issue to the drilling machine as the integral components' position can be adjusted on the column of the machine. There are different types of drilling machines based on their functions and configurations [6]. A sensitive drilling machine is designed for drilling small holes of a maximum of 15.5 mm diameter. The base of the machine can be positioned on a bench or floor with the aid of bolt and nut and it also, consists of a vertical column, a horizontal table, a head supporting the motor and drilling mechanism and a vertical spindle for driving and rotating the drill bit as shown in figure 1. The drill slowly fed to the workpiece using hand. Thus, the operator could sense the progress of drilling, and hence, the machine is referred to as sensitive [7].

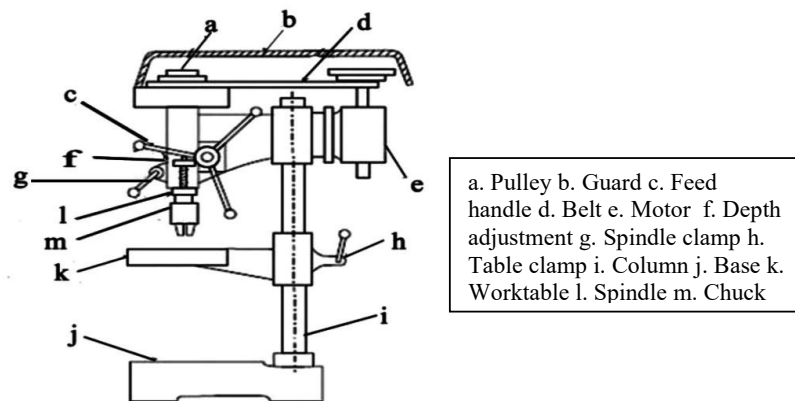


Figure 1: Sensitive Drilling Machine

The upright drilling machine, which has a configuration similar to a sensitive drilling machine (SDM), but larger and heavier than SDM, and this was feed with electrical power. The machine was designed for handling medium-sized workpieces. There are two kinds of upright drilling machine, and these are round column section and box column section. The circular column vertical drilling machine consists of a round column that rises from the base with an arm of table assembly [8]. The arm and the table have three adjustments point for locating the workpiece under the spindle, as shown in figure 2. The arm and table could move up and down on the column and clamp at any position, and the Box column upright drilling machine has the square table fitted on the slides at the front side of the machine column. The heavy box column provides the device with rigidity and strength. The table is lifted or brought low by an elevating screw that enhances support to the table. These features enable the machine to work on more substantial workpieces and make holes more than 50 mm in diameter.

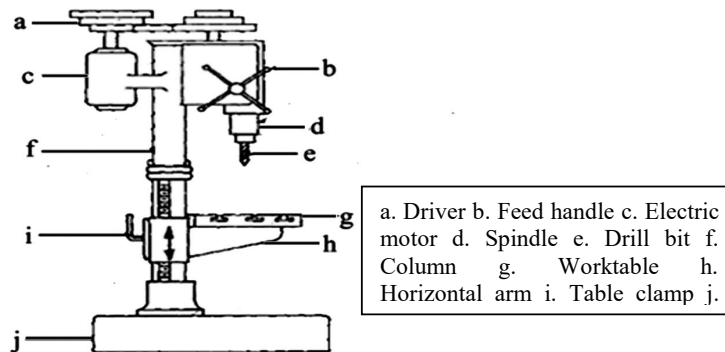


Figure 2: Upright Drilling Machine

Radial drilling machine often used for drilling medium to large and heavy workpieces. The machine consists of a massive round vertical column mounted on a broad base. The column reinforces the radial arm, which can be lowered and lifted to house the workpieces of different heights, as shown in figure 3. The arm can sway around to any position over the work bed. The drill head accommodates the mechanism for feeding and rotating the guide-ways and clamping any required position immediately the spindle is accurately adjusted [4].

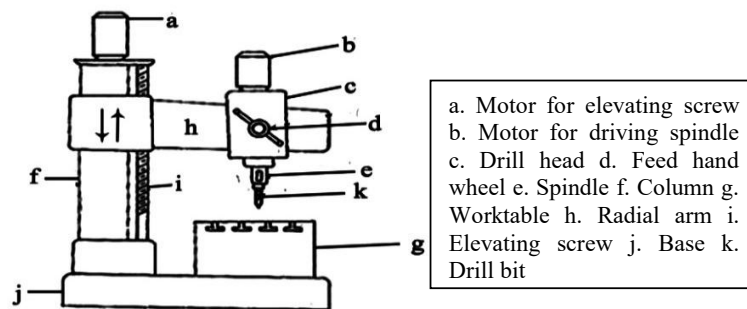


Figure 3: Radial Drilling Machine

Gang drilling machine has several single spindle drilling machine columns side by side on a column base and a collective workpiece. In this kind of drilling machine, four to six spindles are situated side by side [9]. Several operations, including tapping, drilling, counterboring, and reaming, could be performed on the workpiece, and this is achieved by merely shifting the pieces of work from one position to the other on the worktable. Likewise, the gang drilling machine possessed the same long base and table with each spindle having a set up that contains various tools for different operations, as shown in figure 4.

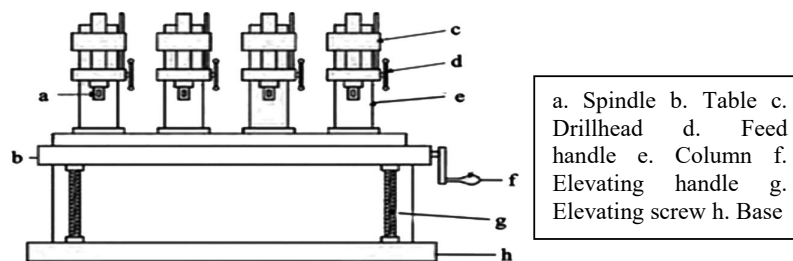


Figure 4: Gang Drilling Machine

A multiple spindle drilling machine is employed to simultaneously drill many holes in a piece of work and replicate the equal model of holes in several similar pieces in a stack production work [10]. The machine has different spindles driven by a single motor, and every spindle hold to drill is fed into the work precisely at the same time, as shown in figure 5.

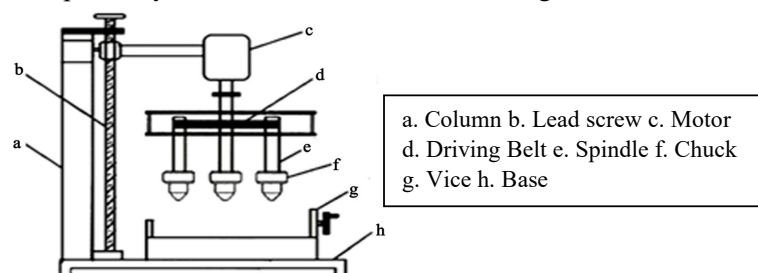


Figure 5: Multiple Spindle Machine

Automated drilling machine can carry out a machining operation at a successive period. The hole drilled is done automatically by engaging the operational switch, which serves as a control for the work process. The workpiece appropriately situated on the base of the machine for the drilling operation, which takes a shorter time to achieve, and immediately the work is done. It was transferred to the next action. However, other advanced types of the same machine operate on a large scale [11].

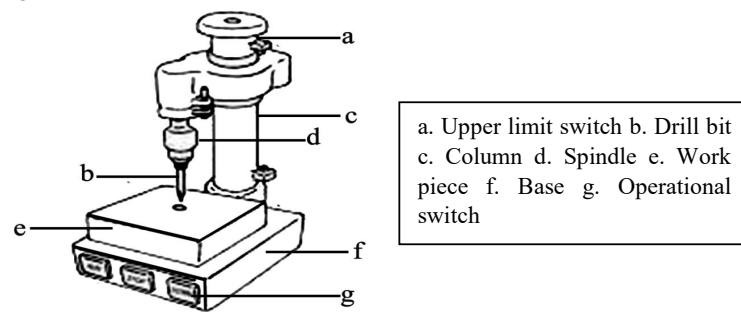


Figure 6: Automated Drilling Machine

The process of drilling deep holes involves using a particular machine designed to drill deep holes through materials such as rifle barrel, crankshafts, connecting rods, and elongated shafts. The machine worked at high speed, and a substantial quantity of coolant is released to the cutting points on the workpiece for cooling the cutting edge of the drill. [12]. The work is usually rotated while the drill is fed into the job, and this enables feeding the drill bit in a linear path, as shown in figure 7.

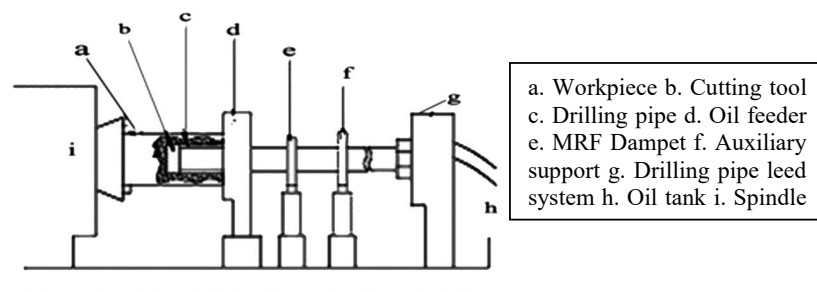


Figure 7: Deep hole drilling machine

The various types of drilling machines mentioned in figures 1 to 7 are heavy duty machines, very expensive, unaffordable and could not be applicable to the villagers whose financial income is low and without access to national grid. This challenge is what instigates the implementation of this work to cater for underdeveloped communities that cannot afford the heavy-duty machine, maintain and generate funds to power such expensive projects and more so, to evaluate and compare the difference between the electrically driven drilling machine and manually operated drilling machine. The construction and application of an absolute manually drilling machine will be of more significant support for the less privilege communities in order to complement their efforts and productivities in terms of wood and metal works. Furthermore, this idea will save the users from unnecessary spending by

moving materials to be drilled to another location far from their immediate environment where the action is needed. Likewise, the stress of using a flat punch to drill hole is prevented.

## 2. Materials and Methods

The table mounted manual drilling machine was developed using locally sourced materials for configuration. The machine's essential parts and the materials' choice were based on the mechanical properties they possessed. Steel alloy was used to fabricate the spindle. High tensile steel was employed for the construction of the arm to prevent the machine from rusting. Likewise, the same material is used for the column, which supports the dead weight of all the components. High-speed steel was used to produce all the bushing integrated into the machine design instead of using bearing because of its low cost, and the material can withstand the heat generated between the bushing and the shaft due to friction. The design was simple with a strong, rigid structure to withstand distortion, deflection, crack, wear, and tear. The physical components of the developed manual drilling machine include pinion, chuck, spindle, bevel gear, column, worktable, flywheel, bracing rod, lead screw, depth adjustment wheel, handle, and holding arm. These components were essential and dependent on one another regardless of their position among the machine structure [13, 14]. The handle serves as a controlling mechanism that synchronizes the other components when an effort is exerted on the handle by spinning it. The resultant effect would be achieved in that single operation. The depth adjustable wheel will be locked against the workpiece. As the handle is controlled manually using hand, the bevel gear engages and produces rotational motion that brings the spindle towards the workpiece on the worktable. The rotation of the handle determines the performance of the work done on the material to be drilled.

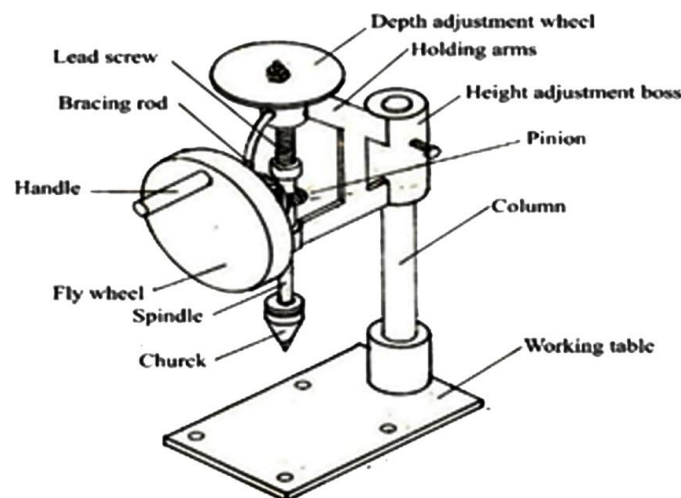


Figure 8: Manual drilling machine

## 3. Result evaluation

Evaluation of parameters used in the design and development of an operated manual drilling machine were determined using equation (1) to (7).

### The circular pitch of the bevel gear

$$P = \frac{\pi D}{N} \quad (\text{m}) \quad [2] \quad (1)$$

Where, P is the circular pitch in the plane of rotation, D is the pitch diameter and N is the number of teeth in bevel gear.

In this work, the velocity ratio (V.R) of the pinion of the bevel gear is selected to be 1.2 to ensure higher mechanical advantage (M.A) with respect to the increase in torque. For an optimum diameter of 150 mm, the number of teeth chosen for the bevel gear was 20 [15].

### **The diameter of the Spindle**

In the developed manual drilling machine, fixation of the limit speed determines the limiting rate of the spindle diameter and more so, the limit speed pivot on the size of the machine, spectrum of tool-work pair achieved machine tool process capability, and this was analyzed using equation (2) to (3) [2, 16].

### **The cutting speed of the machine**

$$V = \frac{\pi DN}{1000} = \frac{ND}{318} \quad (\text{m/min}) \quad (2)$$

Where, V is the cutting speed, D is the diameter of the material, and N is the spindle speed.

The spindle speed of the manual drilling machine

$$N = \frac{V \times 1000}{\pi D} \quad (\text{rpm}) \quad (3)$$

Where, N is the spindle speed of the machine, V is the cutting speed, D is the diameter of a the material

### **Working load of the column**

The working load capacity of the column is expressed using (3) to (4) [17]

$$A = \frac{\pi(2r)^2}{4} \quad (\text{m}^2) \quad (4)$$

$$\text{Moment of inertia} = \frac{\pi(2r)^4}{64} \quad (\text{m}^4) \quad (5)$$

$$\text{Radius of gyration } (R_g) = \frac{I}{A} = \frac{(2r)^2}{16} \quad (\text{m}) \quad (6)$$

Where r is the radius of the material, A is the cross-sectional area

The critical load of Euler

$$P_c = \frac{\pi^2 EI}{L^2} \quad (\text{N}) \quad (7)$$

Where,  $R_g$  is the radius of gyration,  $E$  is the young's modulus of elasticity,  $d$  is the diameter,  $I$  is the moment of inertia,  $L$  connotes length,  $P_c$  is the critical buckling load,  $A$  is the cross-sectional area.

### Conclusion

The simplicity and flexibility of a developed, manually operated drilling machine would positively influence the less privileged communities where electricity was not available. However, the machine's design has made it suitable for rural applications to support small-scale firms or businesses in carrying out their drilling operations without depending on any electrical power source or other renewable energy sources. The developed drilling machine had a screw feed in one minute is 60 mm on non-hardened materials such as wood. Subsequently, for further work, improvement can be made on the spindle's torque and the mechanical advantage, which determines how much work can be done based on the input into the machine.

### Acknowledgment

The authors appreciate the immense contribution of the proprietor's base of Covenant University and Centre for Research Innovation and Discoveries for the privilege of open access publication.

### References

- [1] Prakash R.S., Singh, R.D., Singh, B., Prakash, S.A. and Koshy, V. (2018). Design and Fabrication of Multi Axis Drilling Machine, International Journal of Innovative Research in Technology, 4, (11), 702-706.
- [2] Kiran, R. P. (2015). Workshop Technology, Vikas Publishing House Pvt Limited.
- [3] Afolalu S.A., Samuel O.D., Ikumapayi M.O., Oladipupo S., Emetere M. (2020). Study of Mechanical Behaviour and Characterization of a Steel Joint in MIG Welding Under Varying Fluxes. International Journal of Engineering Research and Technology, 13, 6, 1300-1306.
- [4] Gupta, H.N., Gupta, R.C. and Mittal, A. (2009). Manufacturing Processes, (2<sup>nd</sup> Ed.), New Age International (P) Limited Publishers.
- [5] Hodder and Stoughton (1977). Basic Mech. Engineering. Printed in Great Britain by Westminster press group.
- [6] Black J.T and Kohser R.A. (2012). Materials and Processes in Manufacturing, (11<sup>th</sup> Ed.), John Wiley and Sons, Inc. Printed in the United States of America.
- [7] Singh A.K. and Moona M. (2016). Design of a Universal Micro Radial Drilling Machine. International Journal of Science Technology and Engineering, 2 (9), 154-163.
- [8] Kumar, J.S.S. and Sekhar, S.R.S. (2015). An Experiment Study on the Influence Cutting Parameters on Thrust Force" While Drilling on Different Materials. International Journal and Magazine of Engineering Technology, Management and Research, 2 (1) 327-336.
- [9] Widiyono E., Winarto, Wardhani R., Rusdiyana L. (2011). Engineering Design of a Gang Drilling Machine Equipped with Jig and Fixtures to make A Prototype Machine in Birdcage Production, The Journal for Technology and Science, 22, 4, 214-220.



- [10] Malode, T.B. and Gandhe, R.R. (2016). Designed and fabrication of multi-spindle machine. *International Journal of Innovative Research in Science and Technology*, 3 (2), 290-295.
- [11] Shinde V., Panchal R.N., Panchal J.R. (2016). Semi-automatic Drilling Machine Controller. *International Journal of Innovative Research in Science, Engineering and Technology*, 5 (5), 7522-7529.
- [12] Xavier L.F and Elangova D. (2013). Effective Parameters for Improving Deep Hole Drilling Process by Conventional Method. *International Journal of Engineering Research and Technology*, 2 (3), 1-11.
- [13] Banjo, S.O. Bolaji, B.O., I. Osagie, O.S.I. Fayomi, O.B. Fakehinde, P.S. Olayiwola, S.O. Oyedepo, N.E. Udoeye (2019). Experimental Analysis of the performance characteristics of an eco-friendly HC600a as a retrofitting refrigerant in a thermal system, *Journal of Physics: Conf. Ser.* 1378 (4), 1-8.
- [14] Banjo, S.O. Bolaji, B.O., Ajayi, O.O., Olufemi, B.P., Osagie, I. and Onokwai, A.O. (2019). Performance enhancement using appropriate mass charge of R600a in a developed domestic refrigerator, *IOP Conf. Ser.: Earth and Environmental Science*, 331 (1), 1-8.
- [15] Parashar, B.S.N and Mittal, S.K. (2011). *Elements of Manufacturing Processes*, 10<sup>th</sup> edition, PHI Learning Private Limited, 259-363.
- [16] Kdenigsberger, F. and Tobias, S.A. (1973). *Machine Tools Design and Research Proceeding of the Fourteen International Conference*. The Macmillan Press Limited, London, pg.125-132.
- [17] Kashyap, S.K., Kumar, S., Mallick, M., Singh, R.P., Verma, M. (2018). A comparative study between experimental and theoretical buckling load for hollow steel column. *International Journal of Engineering, Science and Technology*, 10 (3), 27-33.