World Journal of Advanced Engineering Technology and Sciences
eISSN: 2582-8266
Cross Ref DOI: 10.30574/wjaets
Journal homepage: https://wjaets.com/

(REVIEW ARTICLE)

Check for updates

Development of multi spindle drill head for portable drilling machine

Muthuraman S *, Eyad Al Busaidi, Hamim Al Kharusi, Mohamed Al Barwani and Hamood Al Ismaily

Department of Engineering, Mechanical Engineering Section, University of Technology and Applied Sciences, Muscat, Oman.

World Journal of Advanced Engineering Technology and Sciences, 2023, 08(01), 022–028

Publication history: Received on 25 November 2022; revised on 06 January 2023; accepted on 09 January 2023

Article DOI: https://doi.org/10.30574/wjaets.2023.8.1.0182

Abstract

Productivity and quality in Oman factories are crucial to the development of the industry. Manufacturing efficiency is one of the most important variables in determining an organization's productivity. The total machining time can be reduced by merging operations, etc., which in turn increases productivity. With mass production, speed of production is of the utmost importance because there is a smaller pool of potential workers but a much larger quantity to be made. Using multipurpose machinery to crank out these goods is out of the question. The employment of dedicated machinery is the most effective method for increasing both output (productivity) and quality. As a result of creating and developing a multi spindle drilling head attachment, the current radial drilling machine will be more useful and perform better. This paper discusses the development work done for a similar assignment, and it also includes an industry case study.

Keywords: Methods; Multi spindle drilling head; Design; Manufacturing

1. Introduction

When a large number of holes need to be drilled in many different parts of a task, multiple-spindle drilling machines are used. The mechanical sector makes use of multi-spindle head machines to boost the efficiency of machining processes. Drilling machines with several spindles are used in mass production. It has two drill bits so that two holes can be drilled into the same piece of material at once. Multiple work parts are drilled with identical precision to ensure compatibility when used together. The two spindles on this machine are fed into the work piece at the same time by a single motor. You can get feeding motions by either elevating or lowering the work table or the drill's head. If the spindles need to be closer together for one task than another, it can be done. The drill spindles are attached to the main spindle through universal joints, which allow for the center distance between them to be adjusted. In order to have consistent results when drilling into a large amount of material, drill jigs are employed. “[1]”

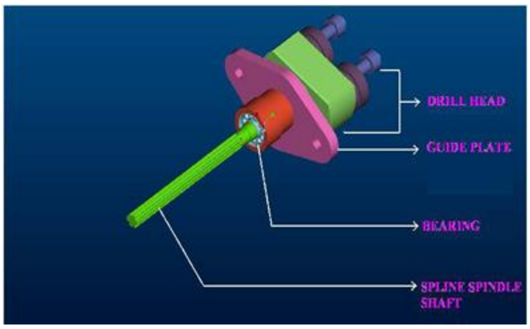

Figure 1 Multi Spindle Drill head

* Corresponding author: Muthuraman S

Customers today expect a perfect blend of quality, quantity, price, and timeliness from the goods they purchase. As a result, it's crucial to boost both output and quality. The use of a multi-spindle drilling head is one method of accomplishing this. Meanwhile, in order to fulfill the final product's quality specifications. "[2]"

2. Methods of multi spindle drill head for portable drilling machine

Multi spindle drilling heads can be used in a variety of ways, including

Head for drilling with multiple spindles that can be adjusted, Useful in many contexts; simply adjust the center distance to a new value. It will allow for more drilling to be done with just one specialized machine. Multi spindle drilling rig with a stationary rig head, where center distance is fixed and cannot be varied. What you have there is a planetary gear train, sometimes known as a compound gear train." [5]"

- Incorporating these multi spindle drilling heads into your operations is a great way to boost productivity.
- Drilling a large number of holes takes the same amount of time as drilling a single hole.
- Positional precision is guaranteed thanks to multi spindle drilling.

For high-volume, mass-produced goods, a multi spindle head with a fixed center of rotation is ideal, while a batch-oriented multi spindle head with an adjustable center of rotation is available. "[3]" An adaptable multi spindle drilling head with a planetary gear train was chosen for this purpose. Several spindle drilling machines, as the name suggests, use multiple spindles to feed drill bits into the work piece at once. Each spindle is driven by a single power head. The spindles can have their center distance modified in any orientation within the drill chuck to suit the task at hand. To achieve this, universal joints are used to link the drill spindles to the primary motor. "[7]"

Drill rotation is generated from the main spindle and the central gear via a set of planetary gears (in mesh with the central gear) and their corresponding flexible shafts. Hole locations on the project dictate the relative positioning of the parallel shafts holding the drills. In order to move the drills of varied sizes and lengths, each shaft has a telescopic section and two universal joints at either end. "[6]"

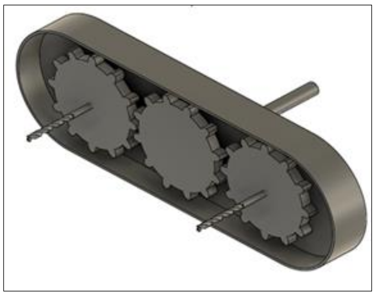

Figure 2 Prototype of dual Spindle Drill head

3. Design

Shaft Design for Combined Bending and Torsion

In actual use, the shaft experiences a synergy of bending and twisting forces.

Shafts are often designed with the following stresses in mind." [4]"

Peak Tensile Strength = 60 N/mm2 Maximal bending stress = 70 N/mm2

Peak shear stress is 40 Newton's per square millimeter.

$$N2 = 1440 * 40 / 80 = N1D1/D2$$

We've settled on a driven pulley diameter that's exactly half as big as the original one in order to cut RPM in half while boosting torque. "[9]"

= 720 RPM.

3.1. Conversion of torque

One-half horse power (horsepower) is 373 watts.

Using the formula: P = 2 N T / 60 = 2 * 3.14 * 720 * T / 60 T = 373 * 60 / 4521.6 = 4.94 N-M

= 4940 Nmm

The 25% Overload Condition

Tmax = 6175 N-mm

3.2. Measuring the greatest possible fractional deformation:

Maximum force, Mmax, equals belt tension multiplied by distance, in Newton-meters.

Shaft bending moment equivalent (Me) = 1/2 * [M +(M2 +T2)1/2] = 12747 N-mm

Taking shaft bending failure into account,

Me = 3.14 / 32 * fb D3

d = 12.25 ≈ 15 mm (nearest) (nearest)

3.3. Pulley shaft construction

Define M as the bending moment

T is the rotational torque

It is recommended that no more than 0.5 horse power (HP) be conveyed using a pulley.

N =460 rpm. (the bare minimum rpm for effective drilling as determined by trial and error) 0.250 = 0.00436 rad is the angle of deflection. “[10]”

The spindle is 15 cm in length. Rigidity modulus, G = 0.84 x 106 kg/cm2 (Plain carbon steel) Let T denote the shaft-transmitted torque: T = P * 60 * 2 * N

= 597 N.mm

3.4. In order to determine the shaft's width

Let d = sleeve diameter

And then by establishing a connection,

T=G Θ \sJ L

d4 = 29.4 cm

A distance of 2.23 centimeters (or 22 mm) is used.

In this case, we need a shaft that is 25 millimeters in diameter.

3.5. Spindle shear stress caused

Choose C-30 for the spindle's material.

Then

бy = 400 N/mm2 (yield stress from PSG data book) (yield stress from PSG data book.)

Assurance factor,

fos = 3

[6y] = 400 \3

= 133 N/mm2

Formula for the shear stress caused by an external force: fs = 0.577 x [6y] = 76 N/mm2.

And then by establishing a connection,

Torque,

T = π \s16x fs x d3

The formula for shear stress is: fs = 194.6 kg / cm2

= 19.46 N/mm2

fs < 76 N/mm2

The conclusion is that design is risk-free.

3.6. Bearing design

Assuming that 12 hours' x pound = 12,000

According to PSG 4.2, L = (c/p) k, and L = 696,000,000 revolutions.

The value of k for a bushing is 3.

C = P x (L)1/k

C = 1000 x (696) 1/3

C = 8862 N C = 886.2 kgf

Bearing, series 62, SKF 6204 as listed in the PSG data book.

d = 20mm.

B= 14mm.

D=47mm.

3.7. Concept for welded part

When using a transverse fillet weld, the maximum load that the plate can support is

ft2 = S2 x L2 x 0.707

Together, the tool's load and friction add up to 30 kilograms, or 294.3 Newtons; so, 294.3 = 0.707 x 5 x 130 feet.

Therefore, let's determine the most secure value for ft. "[11]"

Therefore; ft = 0.64 N/mm2

3.8. Main body specifications

The process sheet for the component main spindle gear is as shown below, which shows the stepwise manufacturing process & machine require to manufacture the part.” [8]”

Material: - M.S.

Raw material Shaft ø 60 * 55 mm

Table 1 Part Specifications

Sr. No.	Part name	Material	Quantity	Specification
1	Body frame	Mild steel	1	500x200 mm made up of mild steel of 3 mm thick
2	Gears	Stainless steel	3	R19 x ⌀ 65 x ⌀ 96 x 20 made up of steel of 2mm
3	Drill bit	HSS	2	100 x 8 x 6 x 40 x 50 x 45° x 124 ° mm made up of steel of thickness 8 mm
4	Nuts and Bolt	steel	2	R19 x ⌀ 65 x ⌀ 96 x 20

3.9. Main body diagram

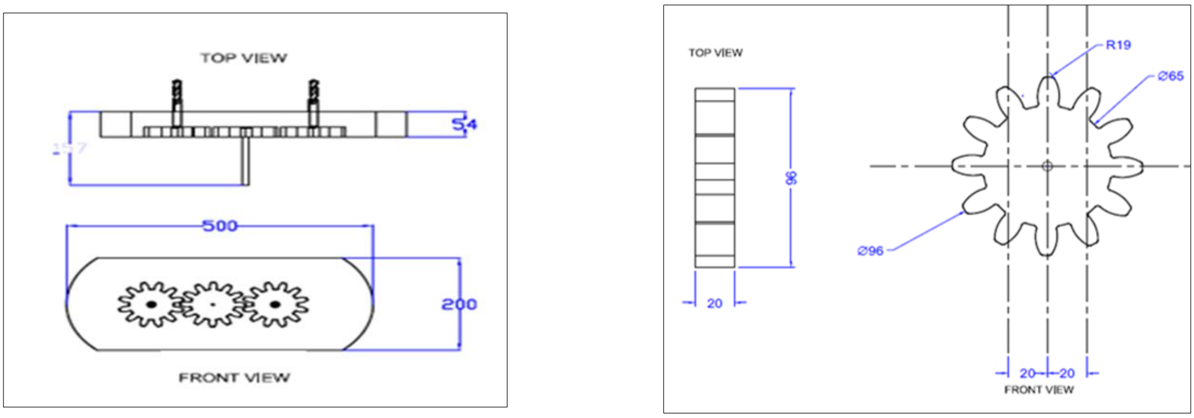

Figure 3 Main Body diagram

3.10. Gear specifications (Big and small)

Raw material: - ø35 X 180 mm 3 Nos.

Pitch Circular Diameter= 33 mm.		Pitch Circular Diameter= 2o mm.	
Tooth Thickness	= 8 mm	Tooth Thickness	= 8 mm
No. Of teeth	= 31	No. Of teeth	= 18
Module	= 1	Module	= 1

Figure 4 Spur gear

3.11. Plate specifications

Material: - M.S.

Quantity: - 1 No’s Row Material: - Plate 130 X 70 X 8

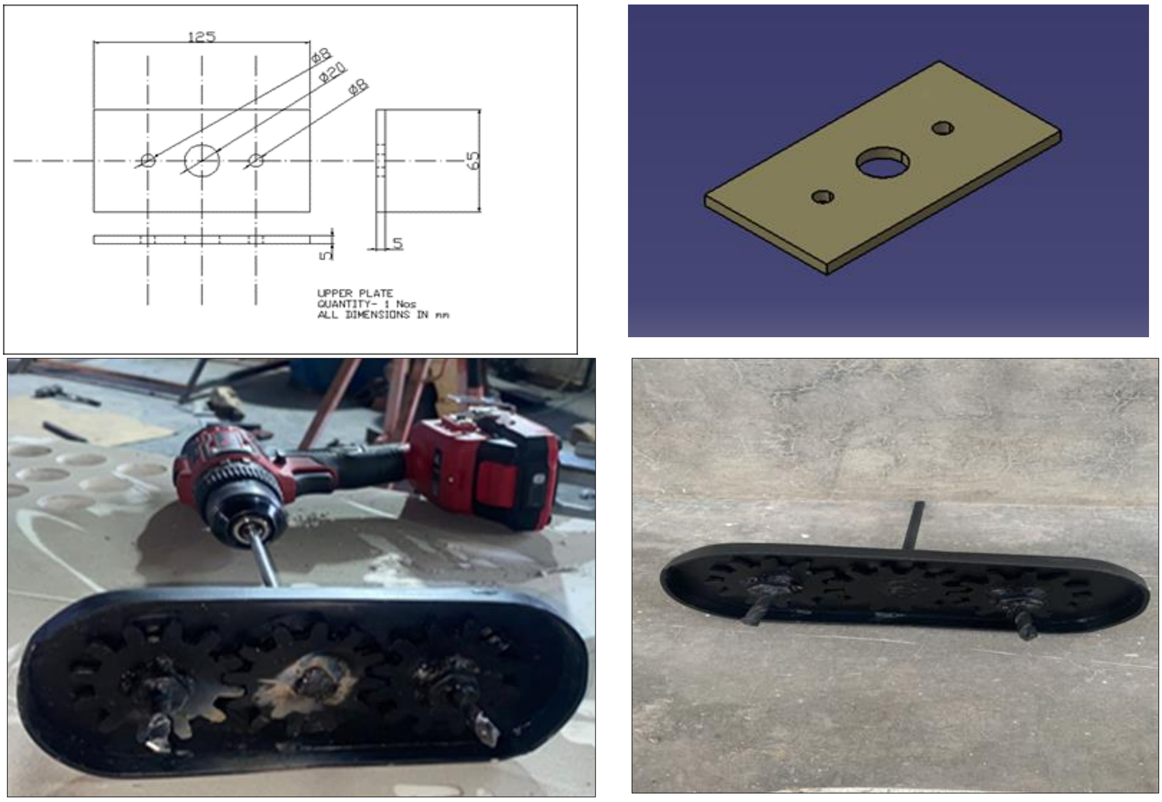

Figure 5 Multi Spindle drill head for portable hand drill machine

4. Conclusion

- This apparatus allows us to simultaneously drill two holes.
- The machine is much easier to transport from one location to another because of its compact design in comparison to its predecessor. Which means that transporting this machine won't be a problem at all. There is a small footprint required overall.
- This machine is easier to use and more effective than its predecessor. It also uses much less energy

Compliance with ethical standards

Acknowledgments

This publication is based upon Students Project work supported by the Department of Engineering, University of Technology and Applied Sciences Muscat

Disclosure of conflict of interest

The Authors certify that it has not been submitted for publication elsewhere. If their work is accepted, the writers promise to follow the journal's copyright policies and adjust the formatting as necessary to fit the journal's standards. The authors state that to the best of their knowledge, they have no financial or personal affiliations that might be seen as influencing the work disclosed in this study.

References

[1] C. Brecher, M. Esser, S. Witt - Interaction of manufacturing process and machine tool. CIRP Annals - Manufacturing Technology 58 (2009) 588–607

[2] Joseph E. Shigley and Charles R. Mischke, Mechanical Engineering Design, McGraw Hill,(2012)

[3] C.K. Chen, F. Freudenstein, "Dynamic analysis of a universal joint with manufacturing tolerances," J. Mech. Transm. Autom. Des., 108 (1986), pp. 524– 532.

[4] F. Duditza, "Transmissions par Cardan" Editions Eyrolles, Paris (1971).

[5] Bajirao H. et.al., "Design and Development of Gearbox for Multi-Spindle Drilling Machine (SPM)", International journal of engineering research & technology (IJERT) Volume 2, Issue 5, ISSN: 2278-0181, May-2013.

[6] Prof. Ms.A.A.Shingavi. et.al., "Design of multiple spindle drilling machine", International journal of research in advent technology (E-ISSN: 2321-9637) Special Issue 1st International conference on advent trends in engineering, science and technology (ICATEST 2015), 08 March 2015.

[7] Olga Guschinskaya, Alexandre Dolgui, Nikolai Guschinsky, and Genrikh Levin – Scheduling for multi-spindle head machines with a mobile table. January 2007 (Research report 2007 – 500 – 002)

[8] Ali Riza Motorcu, Abdulkadir Gullu - Statistical process control in machining, a case study for machine tool capability and process capability. Materials and Design 27 (2006) 364–372

[9] Dolgui, N. Guschinsky & G. Levin – A design of decision support tool (DSS) or mass production machining systems vol. 57, No. 3, 2009.

[10] A.S.Udgave, V.J.Khot, Design & development of multi spindle drilling head, IOSR Journal of Mechanical and Civil Engineering ,ISSN: 2278-1684, PP: 60-69

[11] R. S. Khurmi and J. K. Gupta, A Textbook of Machine Design, Eurasia Publishing House, New Delhi, India, 2002.