



DESIGN AND DEVELOPMENT OF MULTI SPINDLE DRILLING MACHINE



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Abstract- This paper discusses the case study and comparison with productivity of component using traditional drilling machine to Multi spindle drilling machine. The growth of Indian manufacturing sector depends upon many factors, one of the major factors being manufacturing efficiency with which the operation /activities are carried out in the organization. Productivity can be improved by reducing the total machining time, combining the operations, etc. There are frequent needs of tightening and loosening screws, drilling, tapping, boring and grinding operational machines. Huge and complicated designed parts cannot be machined in ordinary machines. In a single machine all the above specified operations can be carried out after drilling operation by removing of drill head and using the required tools like grinding, tapping can etc. By this we can achieve our industrial requirements and production targets. Here we are going to develop a single multi spindle drilling machine which can useful for drilling multiholes and tapping operations in single setup of work piece.

Keywords: Development; design; Drilling; spindle; multi

I. INTRODUCTION

In case of mass production where variety of jobs is less and quantity to be produced is huge, it is very essential to produce the job at a faster rate. This is not possible if we carry out the production by using general purpose machines. The best way to improve the production rate (productivity) along with quality is by use of special purpose machine. Usefulness and performance of the existing radial drilling machine will be increased by designing and manufacturing of multi spindle drilling head attachment.

This paper deals with design and development of multi spindle drilling head for cycle time optimization of the component. Multi-spindle head machines are used in mechanical industry in order to increase the productivity of machining systems. Such machines are equipped by spindle heads that carry multiple tools for performing machining operations.[1]

The most noteworthy aspect when using multi-spindle machines is the cycle time, due to parallel machining the total operating time is dramatically decreased. Added benefits include less chance for error, less accumulated tolerance error, and eliminate tools changes. In such a multi-spindle machine, a part to be machined is fixed on the table. It is not possible neither to fix two or more parts on the table nor use two or more tables at the same machine. Thus, in every moment only one part can be present on such a machine. No part can be loaded before the previous part is not finished. In today's market the customer demands the product of right quality, right quantity, right cost, & at right time. [1]

Therefore it is necessary to improve productivity as well as quality. One way to achieve this is by using multi spindle drilling head. Another way of achieving good quality during production is to use the statistical quality control techniques at every stage of production. If the production is statistically under control the process can continue and there is no need for a change in the process.

There are various methods of multi spindle drilling head are:

A. Adjustable multi spindle drilling head can be used in many components, where change the center distance to some range.

- 1) It will increase drilling capacity in single special purpose machine.
- 2) These are the gear adjustable center drilling head, in which drill Spindle is fitted on slotted plate and the gear is mounted on the drill spindle.
- 3) By changing the gears as per required pitch circle diameter the drill spindle is adjusted in the slotted plate.

B. Fixed Multi spindle drilling head where cannot change the centre distance to some range. Is planetary gear train, compound gear train.

II. PROBLEM DEFINITION

From the survey of complete manufacturing process, it is noted that many of the components got rejected because of non uniform drilling and poor finishing. In the conventional manner only one job can be worked at a time. With increase in productivity demands a special purpose device or attachments are needed which can increase productivity by[6].

A. Performing operations on more than one job at a time, or

B. Performing multiple operations in one cycle.

So In today's market the customer demands the product of right quality, right quantity, right cost, & at right time. Therefore it is necessary to improve productivity as well as quality. It can be achieved by using multi spindle drilling head. For mass production, Multiple-spindle drilling machines are used. It is a time saving technique. Multi-spindle head machines are used in mechanical industry. Therefore it is possible to increase the productivity of machining systems. It is used to drill three holes in a work piece or three different operations simultaneously, in one setting. The holes are drilled on number of work pieces simultaneously. It is easy to make them interchangeable. Three spindles of machine are driven by a single motor simultaneously.



Fig.1 Components to be drilled and tapped

So our main purpose to develop a one Multi Spindle Drill Machine. It consume a less time in Multi Drilling operation or other kind of operation such as boring, tapping, spot facing etc. It not require a different machine setup for operation and it is more easy to operate and simple to handling. It is not require changing tool or drilling bit for operation so it saves time and human effort as well increase productivity.

III. METHODOLOGY

The Multi-spindle drilling attachment is an ideal solution to the above component where multi drilling operations can perform at a time rather than using conventional drilling machine. Also different operations like drilling, tapping can be done in same single setup. The multi-spindle drilling attachment is easy to mount on the drilling machine. Here in the multi-spindle drilling attachment three spindles are driven simultaneously which carry three dill chucks. The drill chucks can receive twist drills and tapping tools to perform the desired operation.

3.1: DESIGN CALCULATION

Data Required for Calculation

- P = Power
- T = Torque
- D = Diameter
- N = Speed of motor
- S = Feed per revolution
- K = Material Factor
- Z = Number of teeth
- Dp = diametral pitch
- B = face width
- T = torsional load
- Cv = velocity factor
- M = Module

A: Drilling and Tapping Design Calculation.

Torque calculation

$$\begin{aligned} \text{Power of Motor} &= 0.5 \times \text{hp} \\ &= 373 \text{ watt} \end{aligned}$$

$$P = 2 \times \pi \times N \times \frac{T}{60}$$

$$\begin{aligned} T &= 373 \times \frac{60}{4521.6} \\ &= 4970 \text{ N mm} \end{aligned}$$

Cutting Speed

For 2 mm

$$\begin{aligned} V &= \frac{\pi \times 2 \times 650}{1000} \\ &= 4.08 \text{ M/min} \end{aligned}$$

For 4.5 mm

$$\begin{aligned} V &= \frac{\pi \times 4.5 \times 650}{1000} \\ &= 9.18 \text{ M/min} \end{aligned}$$

For 5 mm

$$\begin{aligned} V &= \frac{\pi \times 5 \times 650}{1000} \\ &= 10.210 \text{ M/min} \end{aligned}$$

Tapping Speed

$$\begin{aligned} \text{Rpm} &= \frac{\text{cutting speed} \times 3.82}{\text{Tap diameter}} \\ &= \frac{10.210 \times 3.82}{5} \\ &= 7.8 \text{ revolution/minute} \end{aligned}$$

Recommended feeds and speed into material (mild steel) is =30-50

$$\begin{aligned} \text{Select the suitable feed (s)} &= 30 \text{ mm/min} \\ &= 30/650 \\ &= 0.046 \text{ mm/min} \end{aligned}$$

Power require for drilling

For 2 mm

$$p = \frac{1.25 \times D^2 \times K \times N \times (0.056 + 1.5 \times S)}{10^5}$$

$$= 4.0625 \text{ w}$$

For 4.5 mm

$$p = \frac{1.25 \times (4.5)^2 \times K \times N \times (0.056 + 1.5 \times S)}{10^5}$$

$$= 20.56 \text{ w}$$

For 5 mm

$$p = \frac{1.25 \times (5)^2 \times K \times N \times (0.056 + 1.5 \times S)}{10^5}$$

$$= 25.39 \text{ w}$$

Drive ratio for belt

$$DR = \frac{\text{speed of fastest shaft}}{\text{speed of lover shaft}}$$

$$= \frac{1625}{650}$$

$$= 2.5$$

B: Gear box Design calculation

Gear data

No of teeth = 32

Module = 1.5 mm

Addendum (m) = 1.5 mm

Dedendum = 1.88 mm

Pitch cercal diameter of gear = 160 mm

Face width = 10 mm

Torsional load = 4.84 NM

Ultimate tensile strength = 600 N/m

Service factor = 1.5

Diametral pitch = 48

Tangential load

$$T = Pt \times \frac{2}{dp}$$

$$= \frac{4.84 \times 10^3 \times 2}{48}$$

$$Pt = 201.6 \text{ N}$$

Effective load

$$\text{Effective load} = \left(\frac{pt \times cs}{cv} \right)$$

$$= \left(\frac{pt \times 1.5}{cv} \right)$$

$$Cv = \left(\frac{3}{3+V} \right)$$

$$V = \frac{\pi \times 48 \times 650}{60 \times 10^3}$$

$$= 1.63 \text{ m/sec}$$

$$Cv = \left(\frac{3}{3+1.6} \right)$$

$$Cv = 0.65$$

$$\text{Effective load} = \left(\frac{201.6 \times 1.5}{0.65} \right)$$

3.2: 2D-3D Assembly modeling

3.2.1: Construction steps.

1. Pulley manufacturing.
2. Marking a center point on slab.
3. Produce holes in slab for spindle arrangement.

4. Fix the bearings in slabs.
5. Making shafts for spindle.
6. Produce keyways on to the shafts.
7. Mounting gear on shafts.
8. Fixing shafts with bearing.
9. Fix gearbox with drill machine.

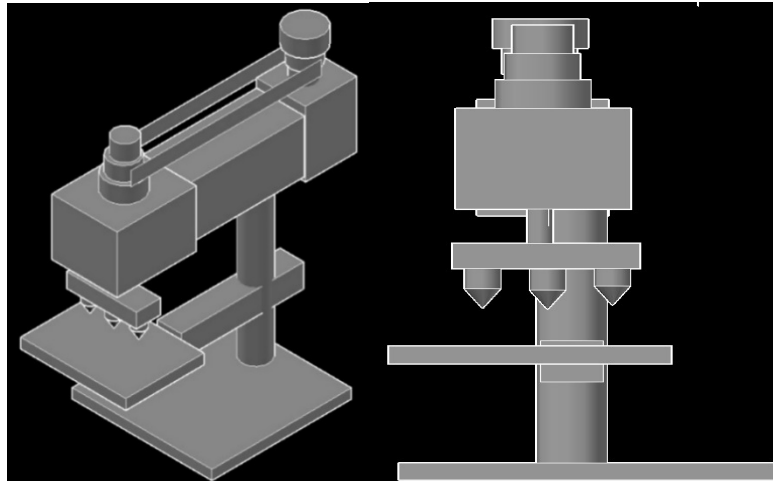


Fig.2. 2D &3D modeling of Multi spindle drilling machine

IV. RESULT & DISSCUSION

In the conventional manner only one operation can be performed at a time, but with increase in productivity demands a special purpose device or attachments are needed which will increase productivity. A multi spindle drilling machine can drill a number of parallel holes simultaneously in a work piece. Multi spindle drilling machines are employed for work of light character, especially repetition work, such as drilling small components for the automobile and Aircraft industries.

4.1: Working of Multi Spindle Drilling Machine

In developed Multi spindle drilling machine have 3 drill spindles, which are driven by a single motor. All the spindles holding the drills are fed into the work piece at the same time. For this purpose, the drill heads can be lowered to the work piece with the handle. It can be moved up and down. Here the work piece is clamped in the vice on the lower table. For movement of three spindlesspur gear train is used to arrange the spindles for operations and power transmission. For tapping the hole the reverse gearing is arranged to reduce the speed of spindle which requires the lower speed.

The components and material which are used in development of Multi Spindle Drilling Machines are shown below:

Table 1: Bill of Material

Sr. No	Name of the Component	Quantity	Material
1	Induction motor	1	----
2	Steep Pully	2	Cast iron
3	V belt	1	Rubber
4	Spindles	3	Mild Steel
5	Bearings	3	Mild Steel
6	Metallic Slab	1	Mild steel
7	Nut- Bolts	5	Mild steel
8	Spur Gears	4	Cast iron
9	Drilling Tool	2	High Carbon Steel
10	Tapping Tool	1	High Carbon Steel
11	Wire	1	Copper
12	Reversible Switch	1	----
13	Body	1	Cast iron

4.2: Cost Analysis

The following table shows the cost of specific component used in development of Multi Spindle Drilling Machine. From the table we can get the overall cost of developing the machine.

Table 2: Cost Analysis

Sr. No.	Name of the Component	Cost (Rs.)
1	Induction motor	1400
2	Steep Pulley	100
3	V belt	100
4	Spindles	450
5	Bearings	170
6	Metallic Slab	270
7	Nut- Bolts	20
8	Spur Gears	675
9	Drilling Tool	60
10	Tapping Tool	90
11	Wire	50
12	Reversible Switch	250
13	Body	3500
14	Fabrication	2500
	Total	RS. 9,725

The overall approximate cost of machine is 10000 RS.

V. CONCLUSION

By using this Machine we have fixed two drilling operations working simultaneously on a single machine in single set up. The parameters of machines for drilling is tapping like maximum Torque, Cutting speed, Gear ratio, power required calculated & defined. By performing the operations on the multi spindle machine we can reduce cost & time of operation. The same machine can be useful in various manufacturing operations in industries for drilling, tapping, boring etc. for various components. The manufacturing cost of two different operations using two different machines is higher than our Multi Spindle Drilling Machine. The overall cost of our developed machine is approximately 10000 RS.

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