International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 04 | Apr 2020 www.irjet.net p-ISSN: 2395-0072

MULTI SPINDLE MACHINE

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Abstract – *In this project we are designing a rotary Multi-Spindle Machine using AC motors, Metal frame & Spindle to perform operations like Drilling, Reaming, Boring etc. There are Multi-Spindle Machines available in market having spindles placed in Linear manner which are using lots of space. In our machine we placed spindles on a rotary frame which uses less floor space of workshop enabling more space for Workers and machines.*

***Key Words*: multi spindle machine, rotary, ac motor, space, operations**

1. INTRODUCTION

Multiple-spindle machines are used for mass production, a great time saver where a number of workpiece having number of operations can be carried out. Multiple-spindle head machines are used in mechanical industry in order to increase the productivity of machining systems. Due to the modernization and globalization, the energy resources are depleting very rapidly & very vastly of this world. Thus the price of these precious resources are going very high in the international market. So the need to use energy more efficiently has become a necessity. The multi-spindle machine is a production type machine. It is used to perform the different operations in a workpiece simultaneously, in one setting. The flexibility achieved using this machine is an added advantage to this machine. Since the machine is manually set, the accuracy of the hole or point at which the hole can be drilled depends on the accuracy with which the machinist sets the end drill bit to the point. Once the drill bit is made to touch the pointer-marked on the workpiece, then the machine is to be started and depth is given using the slide, which gives linear motion to the drill. With multiple axes we aim to achieve 3 types of different drilling operation known to us or required in the given design. This machine contains 3 spindles which are mounted on a head that rotates about its axis. The spindles are driven using 3 A.C. motors which are mounted on each frame. These 3 frames are conjoined with a cylindrical column which rests on a square base plate. The motors are mounted on a sliding plate on each frame which gives vertical linear motion. This vertical linear to and fro motion is achieved by a nut and bolt arrangement like a lead screw giving a stroke length of 105 mm. A locking mechanism for the rotary head is provided to lock the head in a fixed position as per the operator requirement.

2. MULTI SPINDLE MACHINE OPERATION

a) Reaming:

It is a finishing operation of a predrilled hole using a reamer, which has multi longitudinal straight flutes. To obtain a smoothly finished accurate size hole, a slightly under size hole will be drilled first. It is then finished with a reamer. In such a case the amount of material to be removed should not exceed 0.125mm.

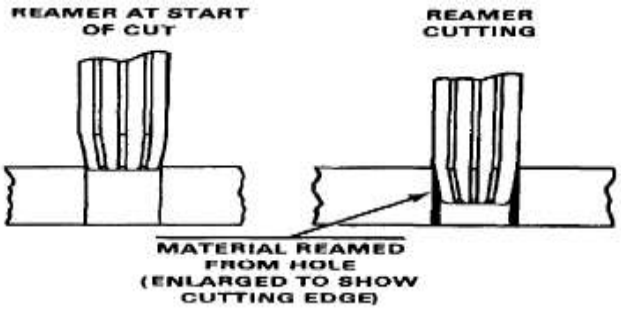


Fig -2.1: Reaming

b) Boring:

It is an enlarging operation of a pre-drilled hole using a boring tool, which has a single cutting point. In order to produce a non-standard size hole, the nearest size hole is drilled first using the standard drill. Later it can be enlarged using a boring tool.

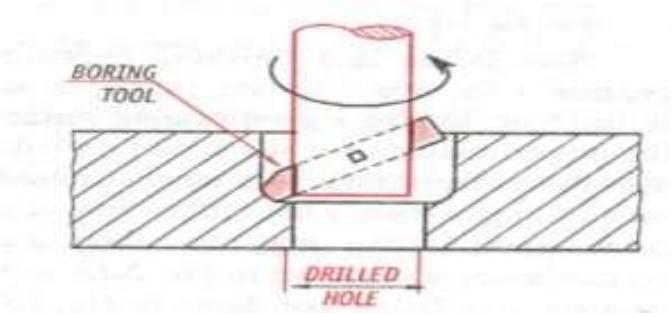


Fig -2.2: Boring

c) Counter-Sinking*:*

It is an operation to produce a conical surface at the end of a predrilled hole, using a counter sink. A conical shaped cutting tool. The angle size of the hole depends on the angle size of the screw thread, whichever is to be seated in it. A countersink hole avoids unwanted projection over the top surface of the work piece, e.g. furniture, joints in doors, windows etc.

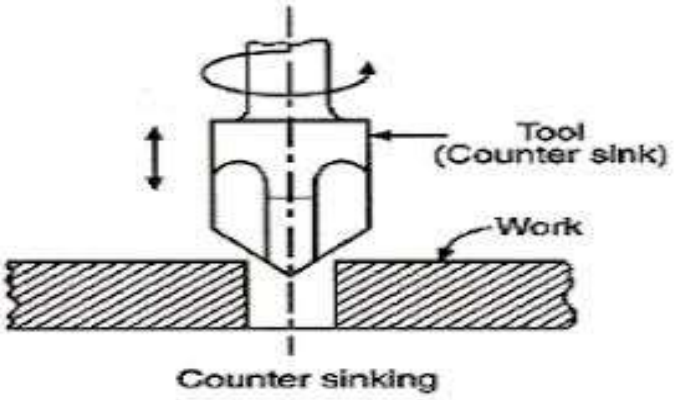


Fig -2.3: Counter sinking

d) Counter-Boring*:*

It is an operation to enlarge one end of the pre drilled hole concentrically to the required depth, using a counter bore tool, to form a square shoulder. The counter bore is used to drive in the socket head screw, bolts, bolts, and pins etc. the pilot of the tool helps to maintain concentricity with the original hole. It is replaceable depending on the required size.

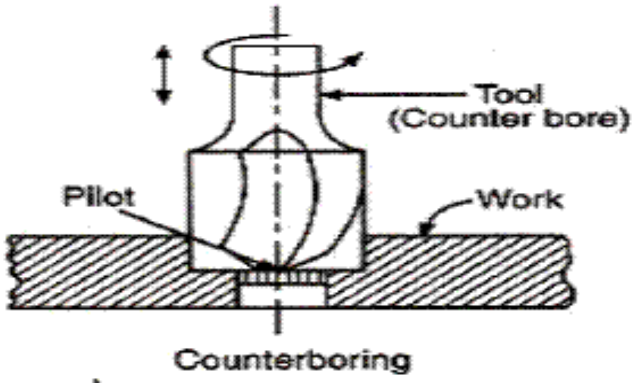


Fig -2.4: Counter boring

e) Spot-Facing:

It is an operation to produce a smooth flat seating at the top of the hole surface for bolt heads, washers, nuts etc. it may be done using counter bores or special spot facing tools.

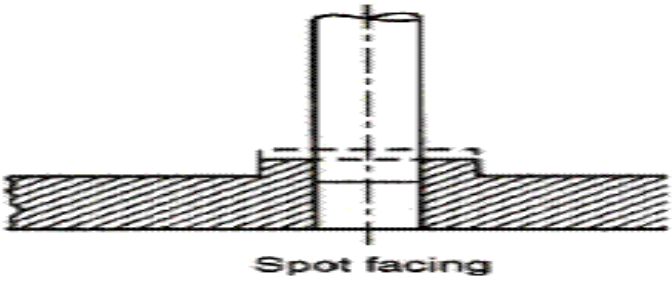


Fig -2.5: Spot facing

f) Tapping:

It is an internal thread generating operation in a predrilled hole, using a set of 3 taps, used one after the in succession. To generate a specific size thread, a nearest drill size is calculated and drilled first. Then using standard size taps, slowly and gradually the threads are generated.

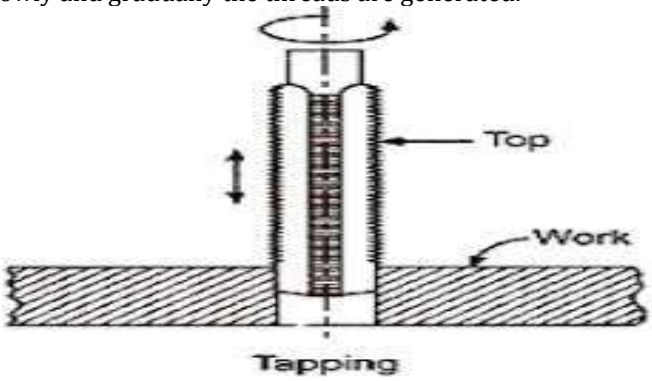


Fig -2.6: Tapping

3. CONSTUCTION

IT CONSISTS OF FOLLOWING PARTS: -

4.1. BASE

It is one of the main part of machine, it carries entire weight of machine, and transfer the weight to the ground. A base supports the column and it is very rigid.

4.2. COLUMN OR PILLAR

The column is vertical member of the machine which supports the head containing all spindles. The column is situated on one side of base. In general, we use a radial column so that the movement of arm is possible in a clockwise or anticlockwise direction.

4.3. UPPER ARM

It is mounted on the column and extends horizontally over the base. It has guideways on which drill head slides. The radial arm moves around the column.

4.4. SPINDLE HEAD

It is mounted on the redial arm and drives the all spindle. In this machine, the spindle head may be adjusted up or down for accommodating different heights of the work in addition to the adjustment.

4.5. SPINDLE SPEED AND FEED MECHANISM

The motor at the top of the spindle head drives the horizontal spindle and the motion is transmitted to the spindle head. Same spindle speed and feed are obtained.

The main advantage of this type of machine is that holes of variable sizes at any point and at any angles can be drilled on the large-sized workpiece without moving the workpiece.

4.6. ELECTRIC MOTOR

In this machine, we use a single phase AC motor. Which can run at an rpm of 800 and low duty machine.

4.7. CHUCK

The chuck is mounted on the lower end of spindle; it holds the drill jigs. Here also a keyhole is provided to change the drill jigs.

Drill chucks are generally self-centering. In a this machine we use three jaw chuck and it is made of alloy steel.

4. WORKING

When the power supply is given, the spindle rotates which was in conjunction with the motor. The Radial arm is adjusted w.r.t the type of operation and height of the workpiece.

Now the drill bit also rotates which was placed in the chuck and which was in connection with the spindle. As the motor starts, the spindle also rotates which can rotate the drill bit.

Now, by the rotation of hand-wheel, the spindle moves up and down in the vertical direction in order to give the necessary amount of feed to the work and this drill bit is used to make the holes on the component placed in the machine vice.

5. CALCULATIONS

Torque Calculation:

Power of motor = 0.067024 hp = 50 watts
$P = 2 \pi N T / 60$ ..... (1)
$50 = 2 * 3.14 * 20000 * T / 60$
$T = 50*60 / 12566.4$
= 0.23873 N-M
= 238.73 N-mm

Feed Rate:
$F = N * Fr$ ..... (2)
Where:
F = feed rate [in/min]
N = spindle speed [rpm]
Fr = feed per revolution [in/rev]

6. Design Specifications of a Multi Spindle Machine

1) Base Material

Base Material	Mild steel
Base Length	152 mm
Base Width	5 mm
Base Height	152 mm

2) Column Material

Column Material	Mild Steel
Column Length	415 mm
Inner Diameter	40 mm
Outer Diameter	50 mm
Type	Hollow Column

3) Rotating shaft Material

Rotating shaft material	Mild Steel
Shaft Length	60 mm
Inner Diameter	50 mm
Outer Diameter	56 mm
Type	Hollow rotating shaft

4) Hollow square Material-1

Hollow square material	Mild Steel
Shaft Length	50 mm
Inner square	25 mm
Outer square	21 mm
Type	Hollow square shaft

5) Hollow square Material-2

Hollow square material	Mild Steel
Shaft Length	155 mm
Inner square	25 mm
Outer square	21 mm
Type	Hollow square shaft

6) Right angle vertical Material

Right angle material	Mild Steel
Plate Length	200 mm
Plate width& height	20 mm
Plate thickness	2 mm
Type	Right angle vertical plate

7) Right angle horizontal Material

Right angle material	Mild Steel
Plate Length	160 mm
Plate width& height	20 mm
Plate thickness	2 mm
Type	Right angle horizontal plate

8) Sliding plate Material

Slider material	Mild Steel
Plate Length	150 mm
Plate width	50 mm
Plate thickness	5 mm
Type	Slider plate

9) Strips Material

Strip material	Mild Steel
Plate Length	200 mm
Plate width	19 mm
Plate thickness	3 mm
Type	Strip plate

10) Manual Spindle

Use	Main Power Supply
Type	3 Spindle Arm
Power	50 Watts
Current	250v / 50 Hz
Speed	2000 rpm
Torque	238.73 Nm

11) Nut and Bolt

3 nut and bolt used (5/8): -

- For feed of spindle arm.
- For movement of drill head along radial arm.
- For movement of radial arm along the column.

12) Drill Specifications

Drill on non-grade metals like: -

- Plastic
- Wood.
- Semiconductor devices.
- Mild steel.
- Aluminum sheets.
- Drill up to 6mm thickness.
- Drill hole of range 0.6mm to 6mm.

13) Feed Details

- Nut and Bolt is used for feed control mechanism of spindle arm.
- Manual feed on rotating hand wheel by 360 degrees.

Design formulae:

Cutting Speed (v): -

It's the peripheral speed of the drill. The cutting speed depends upon the properties of the material being drilled, drill material, drill diameter, rate of speed, coolant used etc.

$V = \pi * D * N$

Where

D = dia of the drill in mm

N = Speed of rotation in rpm

Feed Rate (f): -

It's the movement of drill along the axis (rpm)

Depth of Cut (d): -

The distance from the machined surface to the drill axis.

$d = D / 2$

As the depth of hole increases, the chip ejection becomes more difficult and the fresh cutting fluid is not able to cutting zone. Hence for machining the lengthy hole special type of drill called "gun drill" is used.

Material Removal Rate: -

It's the volume of material removed by the drill per unit time

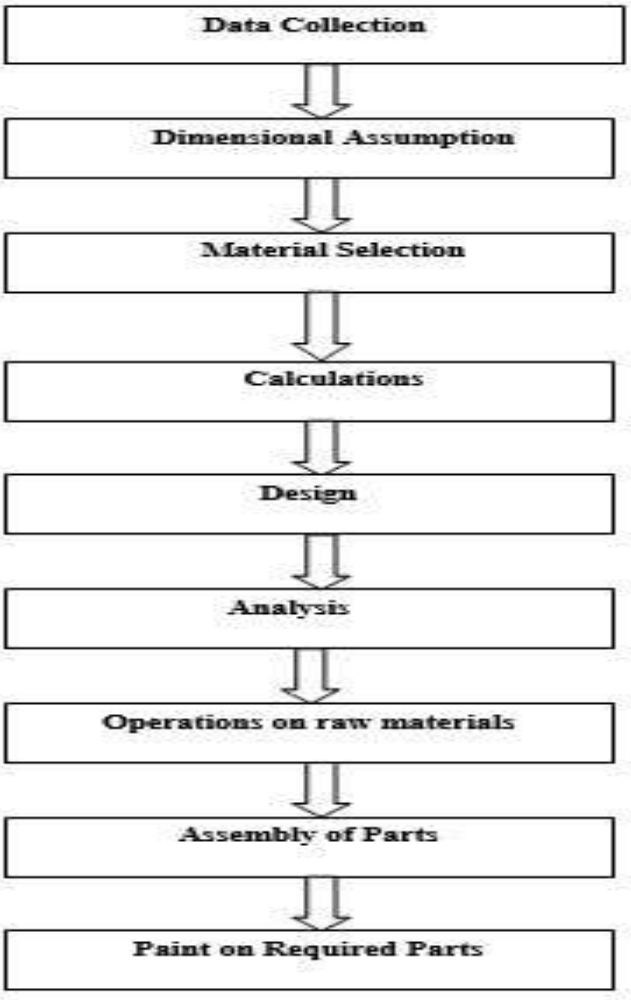
$MRR = (\pi D2 / 4) * f * N \text{ mm3 / min}$

Machining Time (T): -

It depends upon the length (L) of the hole to be drilled, to the Speed (N) and feed (f) of the drill

$T = L / f N \text{ min}$

7. METHEDOLOGY



We collected data about the multi spindle machine which had to be made. We had an idea to modify the current drilling machines available in the market and produce a machine which will help in increase in production consuming lesser time comparatively. At first we had to design the dimensioning required for making a multi-spindle machine & what components had to be considered. We assumed some dimensions of how the machine is to be made and made rough diagram on paper. Then we discussed about what material should the machine be made of, and then we selected mild steel to be used in making of the machine. Then we calculated the total cost which will be put into making of the machine & the calculations required for drilling operations. Then designed the structure of machine in Solid Works to get an idea of how the machine would be looking in actual. Then we gathered all components which were required for the machine. We made a square base with 5 mm thickness which carried all the load of machine. Then we welded a hollow shaft in the center of base perpendicular to it. On the hollow shaft we fixed another hollow shaft which had to rotate or also called as rotary head. We fixed 3 hollow square M.S. angles on the rotary shaft at 120 degrees from each other and on the square angle we welded a frame which was made from M.S. angles in which the spindles and motor were to be fixed. We made a sliding plate to slide in the frame so that the motor will travel in a linear motion upwards and downwards. Then we inserted a bolt into the pre made hole on the top of the frame and welded a nut onto the slider on the back side. We fixed the bolt using washers so that it can't move upward or downward but can rotate on its axis. We welded a handle on the bolt head so that we can grab onto and rotate the bolt which will make the slider to move in a linear motion. We then fixed motor on the front side of slider with the help of zip ties so it won't budge. Then we did the wiring required to run the motors by soldering process. We then fixed the chuck on to the spindle of motor and fixed it using grub screw. We provided switch for each motor to turn it ON/OFF. Then we joined all the wires to a single 3 pin adapter. We started the power supply and the machine turns ON by operating the switch on the frame and thus our project of multi spindle drilling machine was completed.

8. PROJECT ASSEMBLY

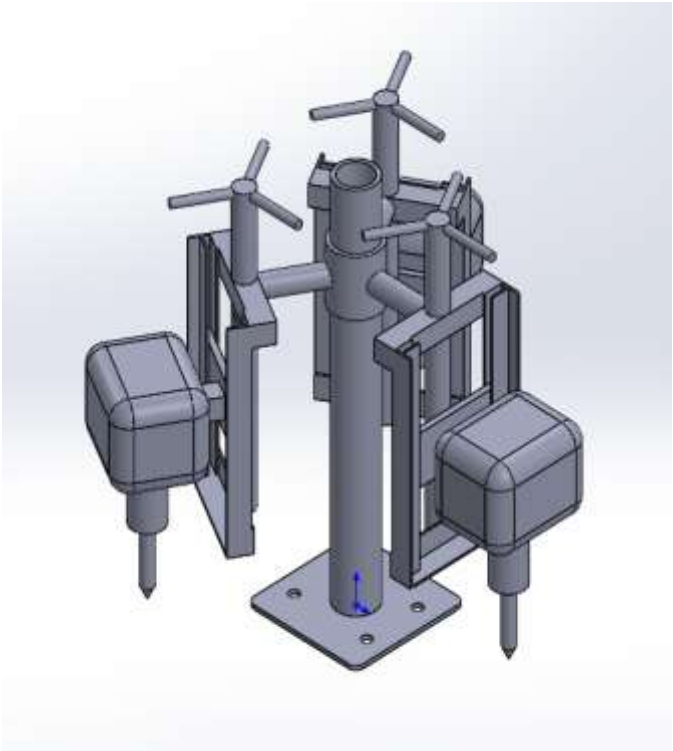


Fig -9.1: Model assembly on solid works

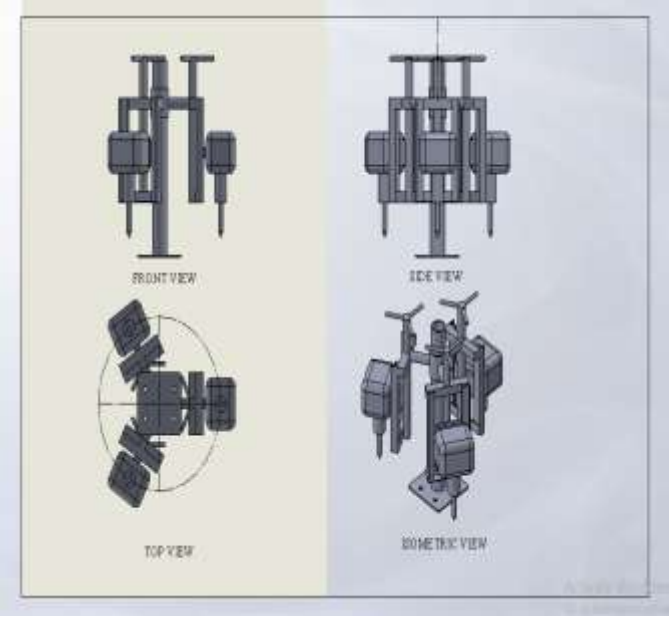


Fig -9.2: Orthographic projection views on solid works

9. CONCLUSIONS

By using multi spindle machine head productivity will increase. Because with the present process one hole produces at a time requires 5.5 minutes for each component (because tool change takes place for drilling 11.5 mm hole. i.e. 6-7 parts are produced during one hour, but by using multi spindle machine head cycle time approximately takes place 1 minutes. i.e. 55-60 parts may produce during one hour. Possibility of hole missing is eliminated, because three operations at a time. The cost per piece is reduced. As seen in conclusion no.1 the production rate is approximately double by using multi spindle machine head. The machine used for multi spindle machine head is same (multi drilling machine) which present uses to produce the part, so machine hour rate remains unchanged. In case of the production of the other batch or other job the same machine can be operated by removing the multi spindle machine attachment.

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