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Design & Development of Twin Drill Head Machine and Drilling Depth Control

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ABSTRACT: The growth of Indian manufacturing sector depends largely on its productivity & quality. Productivity 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. 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) alongwith quality is by use of special purpose machine. Usefulness and performance of the existing radial drilling machine will be increased by designing and development of twin spindle drilling head attachment.

Human force is required to drill the hole, drilling depth cannot be estimated properly, job may spoil due to human errors, and different size holes cannot be drilled without changing the drill bit. Consumes lot of time for doing repeated multiple jobs, these all are the drawbacks. To overcome all these problems, this automated drilling machine is designed which is aimed to drill the holes automatically over a job according to the drilling depth. The main concept of this machine is to drill the holes over particular jobs repeatedly at different depths, sequence is maintained. As the machine contains drill motor, the movement is controlled accurately. This paper deals with such development undertaken for similar job under consideration alongwith industrial case study.

KEYWORDS: Various methods, working of twinspindle drilling machine, Design, Manufacturing.

I. INTRODUCTION

Twin-spindle drilling machines are used for mass production, a great time saver where many pieces of jobs having two holes are to be drilled. Twin-spindle head machines are used in mechanical industry in order to increase the productivity of machining systems. The twin spindle drilling machines is a production type of machine. It is used to drill two holes in a work piece simultaneously, in one setting. The holes are drilled on number of work pieces with the same accuracy, so as to make them interchangeable. This machine has two spindles driven by a single motor and all the spindles are fed in to the work piece simultaneously. Feeding motions are obtained either by raising the work table or by lowering the drills head. In mass production work drill jigs are used for guiding the drills in the work piece so as to achieve accurate results.

Drilling depth cannot be estimated properly, job may spoil due to human errors, and different size holes cannot be drilled without changing the drill bit. Consumes lot of time for doing repeated multiple jobs, these all are the drawbacks. To overcome all these problems, this automated drilling machine is designed which is aimed to drill the holes automatically over a job according to the drilling depth. The main concept of this machine is to drill the holes over particular jobs repeatedly at different depths, sequence is maintained.

- Method Of Multispindle

Fixed Multispindle drilling head

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Where cannot change the centre distance to some range. Is planetary gear train, compound gear train. Features of both the type multispindle drilling head are

a. By using these twinspindle drilling heads, increase the productivity is substantial.

b. Time for one hole drilling is the time for multiple no. of holes drilling.

Conventional drilling machine carries out operations as listed below,

1. Drilling
2. Reaming
3. Tapping
4. Countersinking
5. Spot facing , etc.

II. PRINCIPLE OF MULTIPLE SPINDLE DRILLING

- As the name indicates twin spindle drilling machines have two spindles driven by a single power head, and these two spindles holding the drill bits are fed into the work piece simultaneously.
- The spindles are so constructed that their centre distance can be adjusted in any position within the drill head depending on the job requirement. For this purpose, the drill spindles are connected to the main drive by means of universal joints.

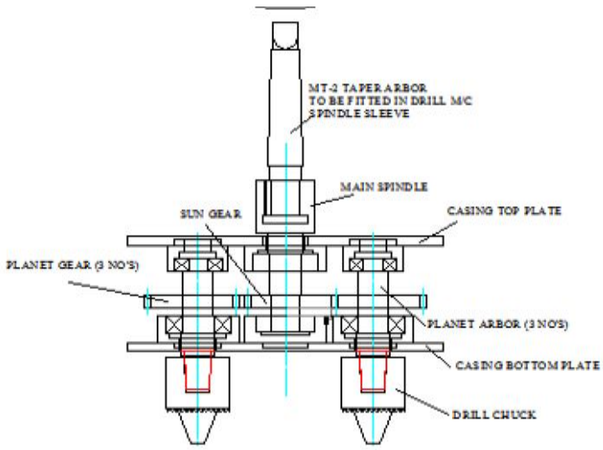

Fig 2.1 Principle of Twin Spindle Drilling

- The rotation of the drills are derived from the main spindle and the central gear through a number of planetary gears in mesh with the central gear and the corresponding flexible shafts.
- There are two planet gears and one sun gear arrangement for transmitting the power from main spindle to planet shaft.

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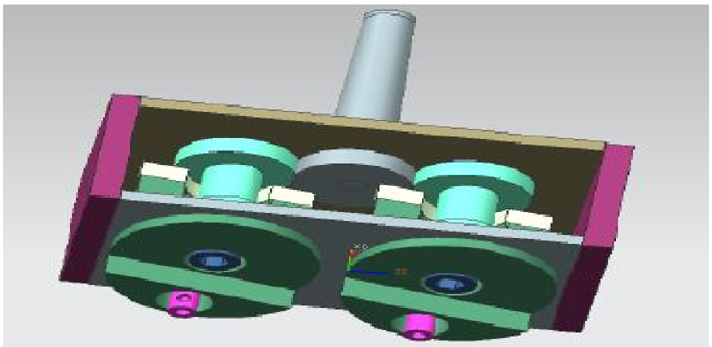

Fig 2.2 Principle of Twin Spindle Drilling in 2D

III. DESIGN PROCEDURE

In our attempt to design a special purpose machine we have adopted a very a very careful approach, the total design work has been divided into two parts mainly;

- System design
- Mechanical design

System design mainly concerns with the various physical constraints and ergonomics, space requirements, arrangement of various components on the main frame of machine no of controls position of these controls ease of maintenance scope of further improvement; height of m/c from ground etc. In Mechanical design the components are categoriesed in two parts.

- Design parts
- Parts to be purchased.

For design parts detail design is done and dimensions thus obtained are compared to next highest dimension which are readily available in market this simplifies the assembly as well as post production servicing work. The various tolerances on work pieces are specified in the manufacturing drawings. The process charts are prepared & passed on to the manufacturing stage .The parts are to be purchased directly are specified &selected from standard catalogues. In system design we mainly concentrate on the following parameter such as System selection based on physical constraints, Arrangement of various components, Components of system, Chances of failure, Servicing facility, Height of m/c from ground, Weight of machine.

3.1Motor Selection

Motor : single Phase AC motor
Power: 440 watt
Speed : 2800 rpm

3.2Power Screw

MOTOR SPECIFICATIONS
TORQUE 3.5kg- cm at 1440 rpm
T= 0.035 kg-m =0.358 N-m at 1440 rpm
Assuming an transmission ratio of 1:40 between motor and the screw using gear box
Tdesign = 40 X 0.358 = 13.74 N-m
The total external torque applied to handle is 13.74 N-m

Therefore,

$(M_t) = 13.74$ N-m---------(A)

$\Rightarrow$ W X T = 13.74 N-m

Where ; T = (dm/2) tan ($\downarrow + \propto$)

Initially assuming dimensions of screw , which we shall check under the given system of forces.
Selecting material combination for screw and nut
(Ref:Pg. No. 170,Design of Machine elements ,V B Bhandari)

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Material Combination	Coefficient of friction(starting)	Coefficient of friction(running)
Soft steel-Bronze	0.10	0.08

Basic dimensions for square threads
(Ref:Pg. No. 5.69,PSG-Design Data)

Nominal Dia	Major Dia(bolt)	Major Dia(nut)	Minor dia	Pitch	Area of Core(mm^2)
20	20	20.5	18	2	254

Design Check
d = Nominal /outer diameter (mm) = 20mm
dc = core / inner diameter (mm) = 18mm
dm = mean diameter (mm) = 19mm
$M_t = W \times (dm/2) \tan(\downarrow + \propto)$
Where , W= Axial load
$\emptyset$ = friction angle
$\propto$ = Heilx angle
Helix angle:-
$\tan \propto = L / \pi\, dm$

For the single start sq. thread lead is same as pitch=2
$\tan\propto = 2 / \pi \times 19$

$\Rightarrow \propto = 1.919^0$
Friction Angle: Ref :- R.S.Khurmi (Table17.5)

Coefficient of friction under different conditions

$\Rightarrow$

Condition	Average coefficient of friction	
	Starting	Running
Average quality of material & workmanship & average running conditions	0.18	0.13

$\mu = \tan \emptyset$
$0.18 = \tan \emptyset$
$\Rightarrow \emptyset = 10.2$
$M_t = W X 19/2 \times \tan(10.2 + 1.9194)$
$M_t = 2.039\ X\ W$ N-mm --------(B)
Equating (A) & (B)
W =6740 N
W = 687 kg

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Material selection:

For screw :- *Ref :- (PSG – 1.12)*

Designation	Tinsel Strength N/mm^2	Yield Strength N/mm^2
EN9	600	380

Direct Tensile or Compressive stress due to an axial load :-

fc $_{act}$ = **W** x dc^2

$$fc_{act} = \frac{6740}{(\pi/4) \times 18^2}$$

nm^2

As fc $_{act}$ < fc $_{a..}$ ompression.

a) Torsional shear stress :-

$T = M_t = \pi/16 \times fs_{act} \times dc^3$

$13.74 \times 10^3 = \pi / 16\ fs_{act} \times (18)^3$

$fs_{act} = 11.998$ N/mm^2

As $fs_{act} < fs_{all}$; the screw is safe in torsion.

C) Bearing Pressure :-

$$P_b = \frac{W}{(\pi/4)\,(do^2 - dc^2)\,n}$$

Where ; P_b = Bearing p

N = No of threads in contact.

Limiting values of bearing pressure:-

Ref :- V B Bhandari. (Table 6.3)

Application of screw	Material		Safe bearing pressure	Rubbing speed
	Screw	Nut	(N/mm^2)	
Screw jack	Steel	Bronze	11-17	Low speed

$P\,b = 6.87 \times 10^3$

$n = 6.87 \times 10^3$

$$n = 6.7\ (\pi/4)\,(20^2 - 18^2)\ 17$$

$\Rightarrow$ n =

b) Shear stress due to axial load :-

$$fs_{act} = \frac{W}{\pi\, n\, dc\, t}$$

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t = width thread = p/2

t= 1 mm

$$fs_{act} = \frac{6.87\times10^3}{\pi\times14\times18\times1}$$

fs_{act} = 8.6?

As ; $fs_{act} < fs_{all}$, th... ır.

3.3DESIGN OF NUT

In design of nut the major dimension is the height or length of the nut. It is decided by considering the bearing criterion. Nut is also required to be safe under shearing . The failure of nut in shearing takes place at its core diameter and the area of core diameter of screw resisting shear is less than the area at the core diameter of nut.

Secondly the materials for nut & screw are different to avoid greater friction at contacts.

Material Selection

Material	Allowable tensile stress N/mm^2	Allowable shear stress N/mm^2
Phospher bronze	400	210

<u>Design the nut</u>

$$f_{bearing} = \frac{W}{\pi/4\,(d^2 - dc^2)\times n}$$

$$= \frac{6.87\times10^3}{\pi/4\,(20^2-18^2)\times 14}$$

n = 6.77

<u>n = 7</u>

AS ; n = no of the threads in contact.

ln = length of nut.

P = Pitch.

$$n = \frac{Ln}{p}$$

$\Rightarrow$ Ln = n x p

= 7 x 2

ln = 14

Normally it is recommended that ratio of length or height of nut (n) to core diameter (dc) should be between 1.2 to 2.5 for solid nuts.

ln = 1.5 x 18

=27 mm

Considering length of nut = 30 mm

b) Shear stress due to axial load.

$$fs_{nut\,(act)} = \frac{w}{\pi\ dc\ x(ln/p)}$$

$$= \frac{6.87\times10^3}{\pi\ x\ 18\ x\ 15}$$

$fs_{nut\,(act)}$ = 8.09?

As $fs_{act} < fs_{all}$ the nut is safe in shear.

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3.4 DESIGN OF WORM WHEEL SHAFT.

T_{Design} = 13.74 Nm.
= 13.74 x 10^3 N.mm

Selection of material
Ref : - PSG Design Data.
Pg No: - 1.10 & 1.12.,1.17

Designation	Ultimate Tensile Strength N/mm^2	Yield strength N/mm^2
EN 24 (40 Ni 2 Cr 1 Mo 28)	720	600

Using ASME code of design;
Allowable shear stress;
Fs_{all} is given stress;
Fs_{all} = 0.30 syt = 0.30 x 600
=180 N/mm^2
Fs_{all} = 0.18 x Sult = 0.18 x 720
= 130 N/mm^2
Considering minimum of the above values;
fs_{all} = 130 N/mm^2
As we are providing key way on shaft;
Reducing above value by 25%.
$\Rightarrow fs_{all}$ = 0.75 x 130
= 97.5 N/mm^2

a) Considering pure torsional load;

$$T_{design} = \frac{\Pi}{16} fs_{all}\ d^3$$

$$\Rightarrow d^3 = \frac{16 \times T}{\Pi \times 97.5}$$

d^3 = 8.95 mm

Selecting minimum diameter of spindle = 17 mm from ease of construction.

3.5 DESIGN (SELECTION OF SCREW BALL BRG)

BALL BEARING SELECTION.

Series 62

ISI NO	Brg Basic Design No (SKF)	d	D1	D	D2	B	Basic capacity	
							C kgf	Co Kgf
15A C02	6002	15	17	32	30	9	2550	4400

P = X Fr + Yfa.
Where ;
P=Equivalent dynamic load ,(N)
X=Radial load constant
Fr= Radial load(H)

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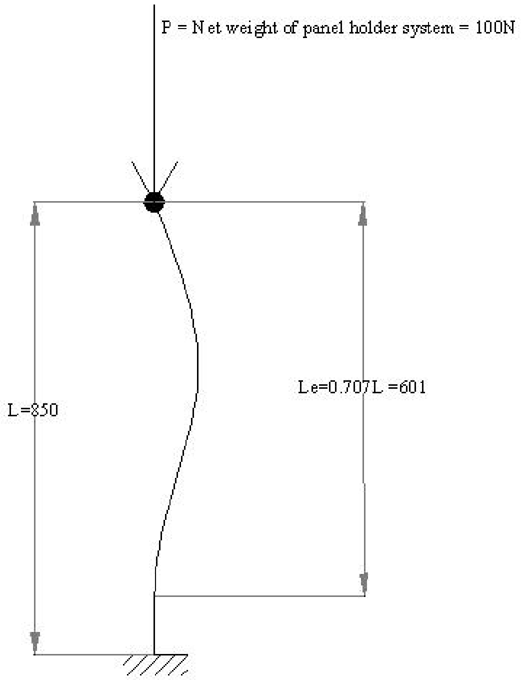
Y = Axial load contact
Fa = Axial load (N)
In our case;
Radial load F_R= Pt = 1540/(29/2) =106.26 N.
$F_a = 0$
P= 106.26 N
$\Rightarrow L = (C/p)^p$
Considering 4000 working hours

$$L = \frac{60\ n\ L\ h}{10^6} = 336 \text{ mrev}$$

$$\Rightarrow 336 = \left(\frac{C}{106.26}\right)^3$$

$\Rightarrow$ C = 738.7 N
AS; required dynamic of bearing is less than the rated dynamic capacity of bearing ;
$\Rightarrow$ Bearing is safe.

3.6 DESIGN OF PILLAR



Rankine formula

$$Pc = \frac{a\ \sigma c}{1 + C(L/r)}$$

where C =1/7500 …..for steel
L=Effective length =601 mm
r = radius of gyration =17.25mm
a= area of cross section = 264 mm^2

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Selection of boom material
Ref :- PSG Design Data.
Pg No :- 1.11

Designation	Ultimate Tensile Strength N/mm^2	Yield strength N/mm^2
C15	340	190

$\sigma c = 190/2 = 95\ N/mm^2$

$$Pc = \frac{264 \times 95}{\dfrac{1 + (601/17.25)}{7500}}$$

$Pc = 25.22 \times 10^3$ N

As the Crippling load 25.22×10^3 N > Actual load (100N)
The boom is safe under buckling criterion

3.7DESIGN OF SPUR GEAR PAIR GEARED MOTOR AND SCREW
Power = 01/15 HP = 50 watt
Speed = 1000 rpm
b = 10 m
Tdesign = 0.48 N.m
Sult pinion = Sult gear = 400 N/mm^2
Service factor (Cs) = 1.5
dp = 20
T = T design = 0.48 N-m

$$\text{Now; } T = Pt \times \frac{dp}{2}$$

$\Rightarrow$Pt = 48 N.

$$Peff = \left(\frac{Pt \times Cs}{Cv}\right) = \left(\frac{32 \times 1.5}{Cv}\right)$$

Neglecting

$\boxed{Peff = 48\ N}$

Lewis Strength equation
WT = Sbym
Where ;

$$Y = 0.484 - \frac{2.86}{Z}$$

$$\Rightarrow yp = 0.484 - \frac{2..86}{10} = 0.198$$

$\Rightarrow$ Syp = 79.2
Syp = Syg = 79.2
W_T = (Syp) x b x m
=79.2 x 10m x m
W_T= 792 m^2----------(B)
Equation (A) & (B)
792.m^2 = 48
$\Rightarrow$m=0.25
selecting standard module =2 Mm

This modul e is selected with the view that the proper mesh between sun –planet-and ring gear is done
GEAR DATA
No. of teeth on sun=10
No. of teeth on planet gear =22
Module = 2mm

IV. NOMENCLATURE

dp = Diametral pitch
m =Module
Td= Tensional Shear Failure of Shaft
Tdesign= Torsional load
fs act = Actual shear stress
fs max = Max. shear stress
fs all =Allowable shear stress
d = Minimum diameter of input shaft
Sult= Ultimate tensile strength
Sylt = Yield tensile strength
Cs =Service factor
Cv =Velocity Factor
Pt=Tangential load
b =Face width (mm)
dp= Pitch circle diameter
Peff= Effective load
WT =Lewis Strength
Y = Lewis Form Factor
Z=Number of teeth P= Power

V. CONSTRUCTION

The twin-spindle drilling attachment is mounted on the drilling machine spindle sleeve, for extra stability an support sleeve may be mounted. The cutting tools as per the job requirements are mounted in the respective three drill chucks of the drilling attachment.

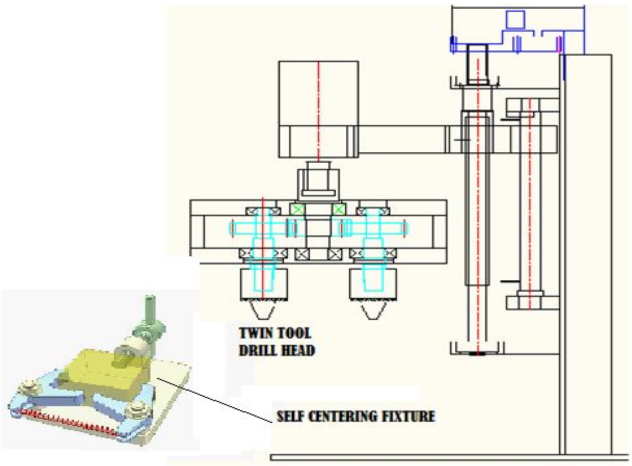

Fig 5.1 construction of Twin drill head machine

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VI. WORKING

When machine is started the drilling machine spindle sleeve drives the arbor and thereby the planet gear system and the drill chucks and respective cutting tools, when the drilling machine spindle is fed in the downward direction the cutting action takes place. For enhancement and fast production an indexable drill jig can be mounted on the drill machine table.
The mechanical transmission section is controlled with stepper motor, based on the drilling depth; the switch restricts the movements of drill motor through stepper motor. Entire process falls under the subject of Mechanics, & various fields of technologies must be included to full-fill the target. The integration of electronic engineering, mechanical engineering, electrical engineering, & control technology is forming a crucial part in this design. Especially the control circuit designed with microcontroller plays dominant roll in this project work. The method of converting rotary to linear motion is implemented in the mechanism. The power screw is designed which operates a stepper motor according to the switch.

VII. ASSEMBLY

Drilling is nothing but the use of a rotating multi-point drill to cut a round hole into a work piece. In a lot of manufacturing processes, one of the most indispensable machining tools is the multiple spindle drilling machine. The drilling machine is commonly called a drill press and is responsible for drilling various sizes of holes in any surface area and to precise depths. Aside from the fact the drilling machine is used primarily in drilling holes, there are a few other functions that the multiple spindle drilling machine is capable of performing. These functions include tapping, spot facing, reaming, countersinking, and counter boring to name a few.

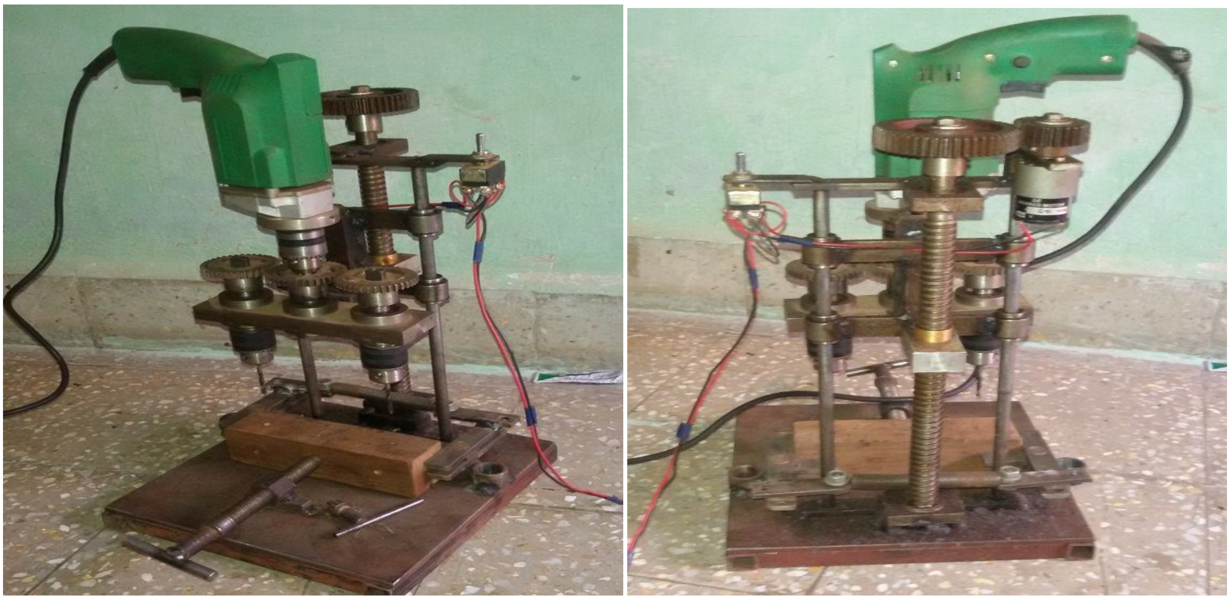

Fig 7.1 assembly of Twin drill head with depth control machine

VIII. CONCLUSION

- With the help of this machine we can drill two holes at a time.
- Desired depth of the hole can be obtained
- The size of machine is smaller than the older machine so it is very simple to move from one place to another. So this machine can be easily transported. The overall space required is also minimum.
- The efficiency of this machine is better than the older machine.
- Large saving in power have been achieved.

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- The machine is very simple to operate.
- No need of skilled operator for the operation.
- Power feed technology is implemented such that human efforts are not required for applying the force during drilling. Stepper motor is used to pull down the drilling machine while drilling.
- In this concept the vertical movement of the drilling machine will be restricted automatically.

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