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DESIGN AND DEVELOPMENT OF MULTI-SPINDLE DRILLING HEAD

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ABSTRACT

This Paper converse about the study of design of multi-spindle drilling machine. In the case of mass production the variety of jobs is less and quantity to be produced is large, it is essential to complete manufacturing at faster rate which is not possible using general purpose machines, and hence new manufacturing setup is required and for this purpose an attachment is proposed for a Special Purpose Machine which is Multi-Spindle drilling head. It is used for drilling multiple holes at the same time. 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. This paper deals with design and development of Multi-spindle head for cycle time optimization of the component.

KEYWORDS: Multi-spindle drilling attachment, Productivity, Special Purpose Machine.

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I. INTRODUCTION

Drilling is the most generally perceived machining process whereby the operation incorporates making round openings in metallic and non-metallic materials. Around 7596 of all metal-cutting method is of the drilling operation. Drills generally have a high length to diameter proportion that is fit for making significant hole, however as a result of its flexibility, vital security measure ought to be taken to keep up accuracy and keep drill from breaking. Drilled holes can be either through holes or visually blind holes. A through holes is made when a drill leaves the inverse side of the work; in blind hole the drill does not leave the work piece. During the operation, chips that are created inside the work piece must exit through the flutes to the outside of the device. As the chip is formed and removed towards the surface, it will produce friction. Friction subsequently warm is likewise created when the drill bit touch the work piece during the hole making process. In this way, chip transfer and cutting fluids are among the most essential components should be consider during this procedure. Regularly, holes created by drilling are greater than the drill diameter and relying upon its applications; the drilled holes will subjected to different operations, for example, reaming or sharpening to better surface complete and dimensional exactness.

Multiple-spindle drilling machines are used for mass production processes, a huge time saver where many pieces of jobs having multiple holes are to be drilled. Multispindle head machines are used in mechanical industries in order to improve the productivity of machining processes. It is used to drill holes for different pitch circle diameters. The centre distance between the spindles can be adjusted in any position as per the requirement of the various jobs. For keeping the centre distance between the gears connected to the main spindle by an Adjustable Transmission System (ATS). 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. The only way to achieve this is by using multi spindle drilling head. Designing of SPM is decided upon the principles of minimization of cost, improved productivity and better safety etc.

II. LITERATURE SURVEY

Geethanjali R, Nirajan Hiremath, Shashi kumar A, Design of Special Purpose Machine for Drilling and Reaming (2016).

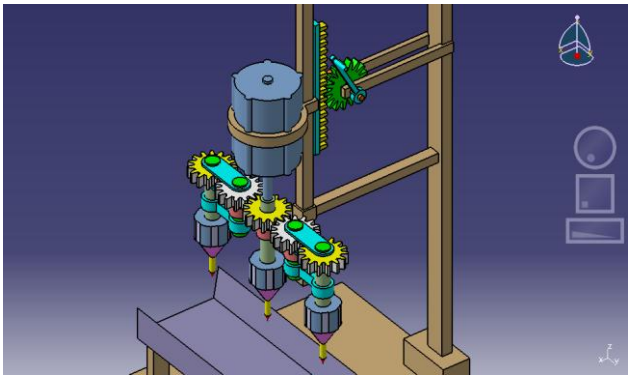
Special purpose machine are those machine which are not accessible off the shelf. These are not secured in standard

manufacturing programs. Therefore they must be designed and tailor made as per the customer's specific requirement. They are additionally called as 'Bespoke Machines'. Exceptional reason machine is a piece of multi-tasking machine. In the event that we think about between common machine and unique reason machine as far as time, costs, number of steps included, and so forth. This is new way to deal with expansion the productivity of association the multi-tasking machine is favored decision. Innovation of special purpose machine is settled on the standards of minimization of cost, enhanced efficiency and enhanced security, better wellbeing and so forth. Which gangs with high beginning venture, higher support cost and so on? Special purpose machine is higher degree system in which human support is supplanted by mechanical, electrical, liquid force advances fit for doing physical exertion and even mental work as if there should arise an occurrence of CNC machine. The special purpose machine and automatic machines are intended to operate continuously for 24 hours a day, with minimum supervision. The special purpose machines are generally product specific and they are required to be designed and developed for every specific requirement. At times it may be possible to cater to the jobs having similar features yet differing in dimensions by using change tooling concept.

A.S. Udgave, Prof.V.J.Khot, Design & development of multi spindle drilling head (MSDH).
Multiple-spindle drilling machines are used for mass production, a great time saver where many pieces of jobs having many holes are to be drilled. Multi-spindle head machines are used in mechanical industry in order to increase the productivity of machining systems. The multiple 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. The centre distance between the spindles can be adjusted in any position as required by the different jobs. For adjusting the centre distance between the drill spindles they are connected to the main spindle by universal joints. In mass production work drill jigs are used for guiding the drills in the work piece so as to achieve accurate results. 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. One way to achieve this is by using multi spindle drilling head. On the other hand, in order to meet quality requirements of final product.

Prof.M.B. Bankar, Prof. P.B. Kadam, Prof. M.R. Todkar, Improvement In Design & Manufacturing Process of Multiple Spindle Drilling Attachment (2016).
In Indian manufacturing sector the growth of manufacturing depends largely on its productivity Drilling machine is used primarily in drilling holes, there are a few other functions that the multiple spindle drilling machine is capable of performing the functions include tapping, spot facing, reaming, countersinking, and counter boring to name a few. The multiple spindle drilling attachment performs basic drilling operations, there are some specific functions that are performed more accurately and conveniently. This attachment works mainly on planetary gear system arrangement. Multi Spindle Drilling Attachment Main function is more than one drilling operation at a time. It has many advantages like increase the production, decrease the operation time, reducing the labor cost, increase productivity and many more. Also reduce the cycles of operations. This is not possible if carry out the production by using general purpose machines. Productivity and performance of the existing drilling machine will be increased by Design & Manufacturing Process of Multiple Spindle Drilling Attachment. This paper deals with improvement in Design & Manufacturing Process of Multiple Spindle Drilling Attachment for cycle time optimization of the component.

III. BASIC PRINCIPLES OF MULTI-SPINDLE DRILLING



1. As the name demonstrates various multiple drilling machines have two spindles driven by a solitary power head and these two spindles holding the drill bits are fed into the work piece simultaneously.

2. The spindles are so constructed that their centre distance can be balanced in any position within the drill head depending upon the job requirement. For this reason Allen Bolt is used.

3. The power from the motor is transmitted by spindle to the centre gear. After the power at centre gear is transmitted to the drilling spindle by compound gear.

DESIGN OF MULTI-SPINDLE DRILLING HEAD

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

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 categories 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.

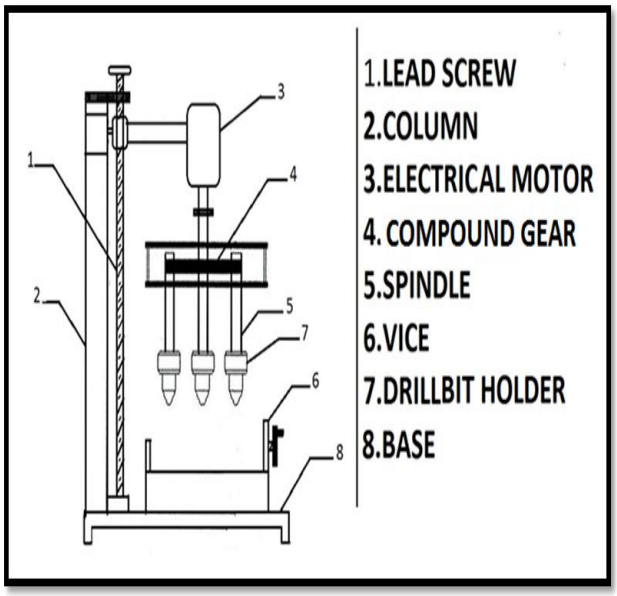


Fig Multi Spindle Setup

COMPONENTS USED

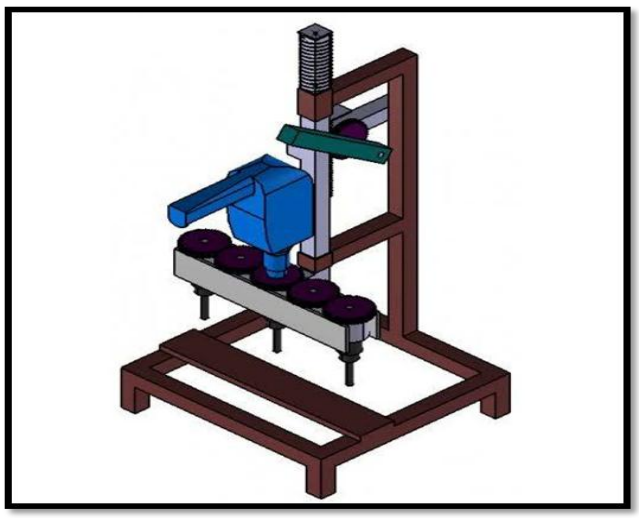
The components used in this multi spindle drill head are
1. Gears
2. Adjustable transmission systems (ATS)
3. Bearing
4. Top plate
5. Bottom plates
6. Drill chuck
7. Drill tool
8. Shank
9.Key
10. Shaft

IV. CALCULATION

CALCULATION OF MOTOR

For determining the motor of required speed the following equation is considered,
$P = (2 \times \Pi \times N \times T)/60$
where,
P = Power,
N = speed in rpm,
T = Torque in N-m
Now,
$P = (2 \times \Pi \times N \times T)/60$
$12 = (2 \times 3.14 \times 60 \times T)/60$
$720 = 3.14 \times 120 \times T$
T = 1.91 N-m
Now,
for calculating the speed of motor for the above torque,
$P = (2 \times \Pi \times N \times T)/60$
$12 = (2 \times \Pi \times N \times 1.91)/60$
$N = (12)/(0.2002)$
N=59.99rpm
Hence, we have selected the speed of the motor as 60 rpm.

DESIGN OF FRAME



Frame design for safety FOR 25*25*2 Square Bar mild steel channel
b = 25 mm, d= 25 mm, t = 3 mm.
Consider the maximum load on the frame to be 50 kg.
Max. Bending moment = force*perpendicular distance
= 50*9.81*450
M = 220725 N-mm
We know,

M / I = σb / y
M = Bending moment
I = Moment of Inertia about axis of bending that is; *Ixx*
y = Distance of the layer at which the bending stress is consider
(We take always the maximum value of *y*, that is, distance of extreme fiber from N.A.)
E = Modulus of elasticity of beam material.
I = bd3 /12
= 25*25^3 / 12
I = 32552.08 mm4
σb = My / I
= 220725*12.5 / 32552.08
σb = 84.76 N /mm2
The allowable shear stress for material is σallow = Syt / fos
Where Syt = yield stress = 210 MPa = 210 N/mm2
And fos is factor of safety = 2
So σallow= 210/2 = 105 MPa = 105 N/mm2
Comparing above we get,
σb < σallow i.e 84.76 < 105 N/mm 2
So design is safe.

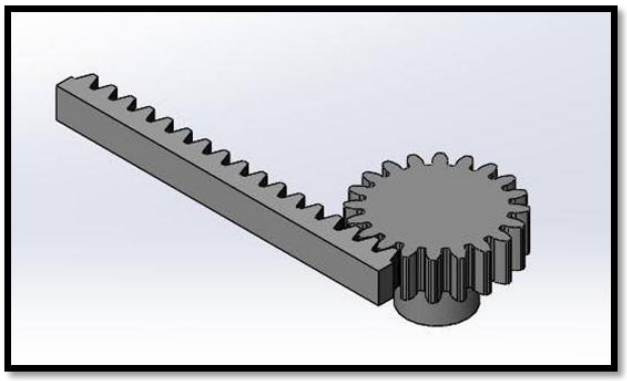
CALCULATION OF WELDED JOINT

Checking the strength of the welded joints for safety
The transverse fillet weld welds the side plate and the edge stiffness plates,
The maximum load which the plate can carry for transverse fillet weld is
P = 0.707 x S x L x ft
Where,
S = factor of safety,
L = contact length = 25mm
The load of shear along with the friction is 50 kg = 500N
Hence, 500 = 0.707 x 3 x 25 x ft
Hence let us find the safe value of 'ft'
Therefore

$$ft = \frac{500}{0.707 \times 3 \times 35}$$

ft = 6.73536 N/mm^2
Since the calculated value of the tensile load is very smaller than The permissible value as ft=56 N/mm^2. Hence welded joint is safe.

CALCULATION OF RACK AND PINION



Material with S_{ut} = 390 N/mm^2 for both pinion and gear.
Total weight on the Rack and Pinion is approx 20 kg.
α = 20˚ with full depth involute.
B = 10 mm
No. of teeth of pinion = 18
Np = 30 rpm
Solution:
For force calculations:
Fr = 20 × 9.81
Fr = 196.2 N

Fr = tanα × Ft
Ft = 539.05 N

$$F_N = \frac{Ft}{Cos\alpha}$$

$$F_N = \frac{539.05}{Cos\ 20}$$

F_N = 573.64 N

Total Load on Gear is F_N = 573.64 N

POWER CALCULATION

$$Power = \frac{Force \times Displacement}{Time}\ watts$$

Let us consider maximum displacement of rack is 5cm

$$Power = \frac{573.64 \times 0.05}{1}$$

Power = 28.682 watts
Now,

$$Power = \frac{2\pi NMt}{60}$$

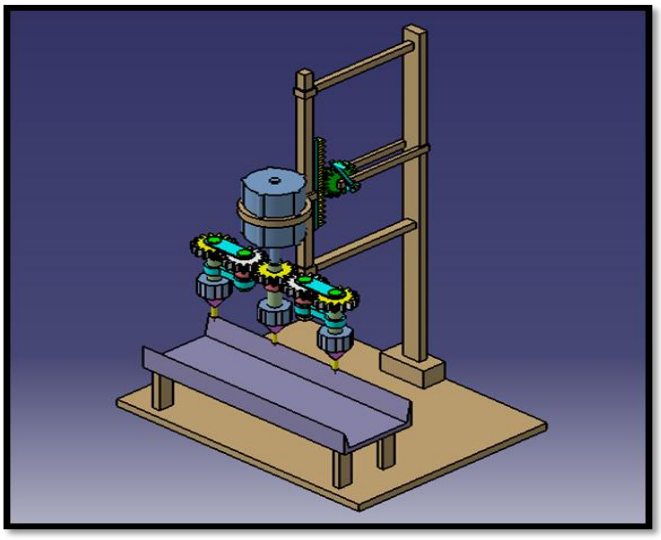
$$\frac{28.682 \times 60}{2\pi \times 30} = M_t$$

M_t = 9.12 N.m
Mt = 9.12 × 10^3 N.mm
We know that,
Torque = Force × Perpendicular displacement
M_t = Ft × r

$$r = \frac{9.12 \times 103}{539.05}$$

r = 16.91 mm
d_p = 2 × 33.83 = 68 mm
i.e Circular pitch = 68mm for pinion

BEAM STRENGTH CALCULATIONS



Beam Strength ($\S_b$)

$$\S_b = \frac{Ft \times d}{\gamma \times b}$$

Where,

F_t = Tangential force

d = Diameter pitch

γ = Lewis form factor

b = Width of pinion

γ = 0.308 for $\S_p$ = no. of teeth = 18

$$d = \frac{\S p}{dp} = \frac{18}{68} = 0.264 \text{ / mm}$$

d = 0.264 mm

$$\S_b = \frac{539.05 \times 0.264}{0.308 \times 10}$$

$\S_b$ = 46.20 N/mm^2

Therefore

$$\sigma_{allow} = \frac{Sut}{FOS} = \frac{390}{1.5} = 260 \text{ N/mm}^2$$

The design is safe.

Calculation for module

$$m = \frac{dp}{\S p} = \frac{68}{18}$$

m = 3.77

module = 4

Now,

Dimensions

Outer diameter for pinion = 2m + dp

= 2 × 4 + 68

= 76 mm

Root diameter = dp – (2m + 2c)

= 68 – (2 × 4 + 2 × 0.25)

= 59.5 mm

Addendum = m = 4

Dedendum = m + c = 4 + 0.25 = 4.25 mm

Max length for rack,

$L = \pi m \times \S p$

= π × 4 × 18

= 226.19 mm

Width of pinion = 40 mm

Width of rack = 10×m = 40 mm

V. METHODOLOGY

- We started the work of this project with literature survey. We gathered many research papers which are relevant to this topic. After going through these papers, we learnt about 90 degree steering system.
- After that the components were decided.
- After that we selected the materials for the components based on mechanical properties.
- We have done the calculations for the components.
- After doing the calculations of components, the 3D model is done with the help of CATIA software.
- The components will be manufactured and then assembled together.
- The testing will be carried out and then results and conclusion will be drawn.

VI. CONCLUSION

- By using Multi-Spindle drilling head productivity will be increased.
- Multiple holes can be drilled at a time.
- Multi-Spindle drilling head will reduce the operation cost.
- Multi drilling operation takes place in one cycle so holes will not be skipped.
- This Attachment is beneficial for mass production.

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