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

Design of Multiple Spindle Drilling Machine

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Abstract— This paper discuss the case study and comparison of productivity of component using conventional radial drilling machineand special purpose machine. 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 theproduction 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 manufacturing of multispindle drilling head attachment.This paper deals with design and development of multispindle drilling head for cycle time optimization of the component.

1. INTRODUCTION

Conventional drilling machine carries out operations as listed below,

- Drilling
- Reaming
- Countersinking
- Spot facing, etc.

In this paper the following studies are carried out Time saved by component handling (loading and unloading), using hydraulic clamping, Increase in productivity both qualitative and quantitative, Less human intervention, indirectly reduction in operator fatigue, Increase the profit of company. Special purpose machine is part of multi-tasking machine. This is new approach to increase theproductivity of organization. If we compare betweenordinary machine and special purpose machine in terms of time, costs, number of steps involved, etc. The multi-tasking machine is preferred choice. The most noteworthy aspect when using multi-spindle machines is the cycle time, due to parallel machining the total operating time is dramatically decreased.

2. PROBLEM DEFINITION

In the conventional manner only one job can be worked at a time for either of the above operations, but with increase in productivity demands a special purpose device or attachments is need which will increase productivity by,

1. Performing operations on more than one job at a time,
2. Performing multiple operations in one cycle
3. Indexing capability to sequence operations one after another.

2.1. Solution

The Multi-spindle drilling attachment is an ideal solution to the above problem where in the conventional drilling machine is used to perform three operations at a time, so also different operations like drilling, reaming, countersinking or spot facing can be done simultaneously.The multi-spindle drilling attachment is easy to mount on the drilling machine, where in the MT-2 taper arbor directly fits into the drilling machine sleeve; if necessary an support sleeve can be attached to the casing plate for extra stability.In the multi-spindle drilling attachment three spindle are driven simultaneously which carry three dill chucks. The drill chucks can receive twist drills, reamers, countersink drills or spot facing cutters to perform the desired operation.

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. Another way ofachieving good quality during production is to use the statistical quality control techniques at every stage ofproduction. If the production is statistically under control the process can continue and there is no need for achange in the process. However, if it is not statistically under control, the assignable causes should bediscovered and removed from the process.

3. VARIOUS METHODSOF MULTISPINDLE

The various methods of multispindle drilling head are:
3.1 Adjustable multispindle drilling head: Can be used in many components, where we can drill six work pieces at a time and also it has adjustment lever which can separate three drilling spindle. So we can drill three or six work piece according to.requirement

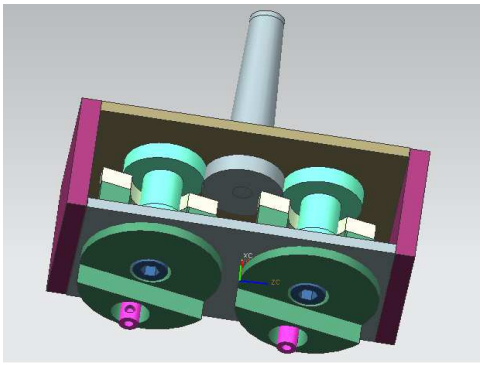
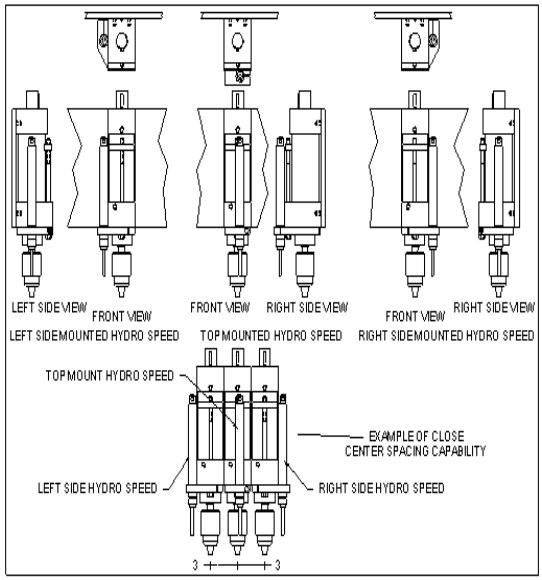


Fig.3.1adjustable drilling machine

3.2 Fixed Multispindle drilling head :
Where we cannot separate the spindle according to requirement. Is planetary gear train, compound gear train.
Features of both the type multispindle drilling head are
a. By using these multispindle drilling heads, increase the productivity is substantial.
b. Time for one hole drilling is the time for multiple no. of holes drilling.
c. Multispindle drilling ensures the positional accuracy.
Multispindle heads can be of fixed centre construction for mass and large batch production and for batch production, adjustable centre type design is offered Here planetary gear train type adjustable multispindle drilling head is selected.

Layout



It includes the six spindles which is arrange in circular shape which are shown in above figure which are attached with each other with the help of planetary gear. The whole assembly is connected to main arbour shaft.

4.DESIGN

4.1.MotorSelection

Thus selecting a motor of the following specifications
3 phase induction motor
Power = 0.5 hp = 375 Watt
Speed = 1440 rpm

4.2.To calculate arbor shaft

$$POWER=\frac{2*\pi*N*T}{60}$$

$$T_m=\frac{P*60}{2*N*\pi}$$

$$=\frac{375*60}{2*1440*\pi}$$

=2.48 Nm

$= 2.48*10^3$Nmm

Motor is 375 watt, run at 1440rpm, connected to drilling machine spindle by belt pulley arrangement

of 1:3 ratio, considering 65% efficiency of belt drive; torque at the 6 arbor shaft is given by

Total no. of Arbor shaft= 6

$T_{arb}=T_m*6*0.65$

$=2.48*10^3*6*0.65$

$= 9.69*10^3$ Nmm

4.3. Check the Safetyness of Shaft

Diameter of Shaft = 15mm

Tortional shear $=\tau_{act}=\frac{16*T_{arb}}{\pi d^3}$

$=\frac{16*9.69*10^3}{\pi 15^3}$

=14.62 N/mm

Shear force for standard material is = 55N/mm^2

Therefore ,

$\tau_{act.}<\tau_{all}$

Therefore design of shaft is safety.

4.4. Design of key

Selecting parallel key and its dimension from design databook.

Shaft diameter	above	12
	Upto	17
Key dimension	width	5
	height	5

S_{ut} of key material is

S_{ut} = 210 N/mm^2

τ_{all} = 55 N/mm^2

4.1 Direct shear failure

$T = L*\frac{d}{2}\frac{t}{2}*\tau_{act}$

$\tau_{act}=\frac{T}{\frac{d}{2}\frac{t}{2}*L}$

$=\frac{2.48*10^3*4}{25*5*15}$

=5.29 N/mm^2

Therefore $\tau_{act}<\tau_{all}$

Hence design of key is safe.

4.5.Design of gear box:

Planet gear;

Diameter= 60mm

No. of teeth= 30

Module= $\frac{d}{t}=\frac{60}{30}=2$

Sun gear:

Moule =2

No of teeth =68

Diameter= module*teeth

=2*68=136mm

Speed=$\frac{1440}{6}$=240 rpm

Power=375 watt

Facewidth= b=10m

T_m= 9.69Nm=9.69*10^{3}Nmm

S_{ut} of pinion and gear is 550N/mm^2

N_f=1.5(assume)

Diameter of main shaft is= D_p=35mm

$T=f_t*\frac{Dp}{2}$

$F_t= 9.69*10^3*\frac{2}{35}$

F_t=553.71N

$F_{eff}=\frac{f_t}{k_v}*k$

$K_v=\frac{3}{3+V}$ (assume)

$V=\frac{\pi*D*N}{60}$

= 0.43m/s

K_v= 0.87

F_{eff}=954 N

Then by Lewies Equation

$F_b= 6_b*b*m*y$

$Y_p=0.484-\frac{2.86}{30}$ = 0.3886

&

$Y_g=0.484-\frac{2.86}{68}$ = 0.4419

$6_b=\frac{550}{1.5}$=366.66

As the both pinion and gear have same material therefore only consider lewies factor y and find weaker member.

As the $Y_p<Y_g$

Therefore pinion is weaker than gear. For designing pinion

$F_b=6_b*b*Y*m$

=366.66*10m*0.3886*m

$= 1424.84m^2$

$F_b=f_{eff}*N_f$

$1424.84m^2=954*1.5$

$m^2= 1.4935$

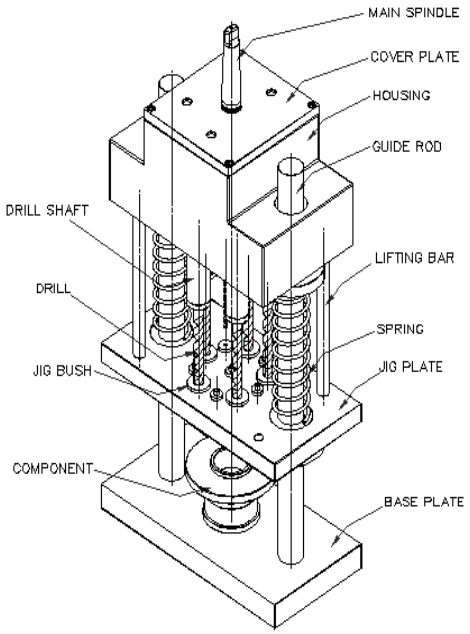
$m = 1.22$

therefore select the standard module 1.5
m = 1.5

4.6. Gear data

No of teeth
a) Sun gear = 68
b) Planet gear = 30
Module = 1.5

5. WORKING



The multi-spindle drilling attachment is mounted on the drilling machine spindle sleeve, for extra stability and support sleeve may be mounted. The cutting tools as per the hob requirements are mounted in the respective six drill chucks of the drilling attachment. 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 inthe downward direction the cutting action takes place.

For enhancement and fast production an inflexible drill jig can be mounted on the drill machine table. By using this multispindle drilling head 6 holes of different diameter can be drill at a time. And also it has a adjustment that we can separate the three arbor shaft from main shaft, so we can drill three work piece at a time as requirement. Drive is given by motion to main spindle, which drives planetary gear trainfitted in the housing, then drill shafts rotates as per the gear ratio.

6. ADVANTAGES

1. Six spindles operate simultaneously.
2. Six similar operations can be performed at same time.
3. Permutation of operations can be performed at same time.
4. Compact in size, low weight and stable
5. Low cost of manufacture.

7. APPLICATIONS

1 .Drilling.
2. Reaming.
3. Countersinking.
4. Spot facing.

8. CONCLUSION

1) By using multispindle drilling head productivity will increase. Because with the present process one holeproduces at a time requires 4 minutes for each component (because tool change takes place for drilling 5mmhole (for M6x1 tap)). i.e. 12-15 parts are produced during one hour, but by using multispindle drilling headcycle time approximately takes place 1 minutes. i.e. 55-60 parts may produce during one hour.
2) Possibility of hole missing is eliminated, because six holes drilled at a time.
3) The cost per piece is reduced. As seen in conclusion no.1 the production rate is approximately double byusingmultispindle drilling head. The machine used for multispindle drilling head is same (Radial drillingmachine) which present uses to produce the part, so machine hour rate remains unchanged.

Future scope

- Now a days the multispindle drilling machine used are operated by single lever ,which control all spindles at a time.
- The new idea is that ,we can operate two or three spindles at a time according to requirement.

- Other operations such as reaming ,tapping,boring can be done on same head .

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