DESIGN AND DEVELOPMENT OF MULTI SPINDLE DRILLING SPECIAL PURPOSE MACHINE FOR PUMP COVER

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Abstract - This paper converse about the study of design of multi spindle drilling machine. In the case of mass production where variety of jobs is less and quantity to be produced is large, it is very essential to manufacture the job at a faster rate. This is not possible if we produce by using general purpose machines. The purpose is to minimize the production time for drilling multiple holes in a work piece of different Pitch Circle Diameters (PCD). In this work we have to drill 4 holes of different diameter at a time. This paper deals with design and development of multi spindle drilling head to maximize the improvement of cycle time of component.

Key Words: design, drilling machine, mass production, multiple holes, multi spindle

1. INTRODUCTION

Multiple-spindle drilling machines are used for mass production as it saves large time where many pieces of jobs having many holes are to be drilled. 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. The most important aspect when using multi-spindle machines is the cycle time, due to parallel machining the total operating time is decreased. Added benefits include less chance for error, less accumulated tolerance error, and eliminate tools changes. The proposed work machine has four spindles driven by a single motor and all the spindles are in fixed position. The motion of feeding work piece obtained by using hydraulic operated cylinder moving towards the drills head. The centre distance between the spindles is fixed as job requirement. The overall work is to design special purpose machine which reduce cycle time of operation and main objective it to increase productivity in large extent as compared to conventional drilling machine.

2. PROBLEM STATEMENT

As many industries use radial drilling machines, it has many disadvantages like more cycle time, less production rate, less accuracy. Hence using automation for drilling machine special purpose machine is beneficial for them.

3. COMPONENT

Fig-1: 3-D view of part is shown in above
Red colour indicate holes to be drilled.

4. DESIGN

Fig-2: Three dimensional configuration diagram of Gearbox
5. FORCE AND POWER CALCULATION

Component material: Aluminum alloy

From CMTI book, cutting speed is 40 m/min

Therefore, rpm of spindle for 3 mm drill is \(N = 4244\) rpm

feed is \(S = 0.05-01\) mm/rev

Material factor (K):

For aluminium alloy component \(K = 0.55\)

Power at spindle is given by,

For Ø 3 mm hole,

\[
P = \frac{1.25 \times d^2 \times K \times n \times (0.056 + 1.5 \times S)}{10^5}
\]  
(From CMTI table no. 260)

\(P = 0.05409\) kw

This power is required for one spindle, for two spindles,

Total power \(= 2 \times 0.05409\)

\(= 0.10818\) kw

Torque coming on spindle is given by,

\[
T_s = \frac{975 \times P \times 9.81}{N}
\]  
(From CMTI table no. 260)

\(T_s = \frac{975 \times 0.10818 \times 9.81}{4244}\)

\(T_s = 243.8\) N

Thrust coming on single spindle is given by,

\[
T_h = 1.16 \times k \times d \times (100 \times S)^{0.05} \times 9.81
\]  
(From CMTI table no. 260)

\(T_h = 1.16 \times 0.55 \times 3 \times (100 \times 0.1)^{0.05} \times 9.81\)

\(T_h = 132.92\) N

Thrust coming two spindles \(= 2 \times 132.92\)

\(= 265.84\) N

For drill Ø 8 mm, cutting speed \(V = 42\) m/min

Speed of spindle \(N = 1671\) rpm

Feed range for Ø 8 mm hole, \(S = 0.15\) mm/rev

Power at spindle \(= 0.2066\) kw

Torque on spindle \(= 1182.5\) N-mm

Thrust force coming on spindle \(T_h = 500.33\) N

For drill Ø 12 mm, Cutting speed \(V = 40\) m/min

Speed of spindle \(N = 1061\) rpm

Feed for Ø 12 mm hole So, \(S = 0.20\) mm/rev

Power at spindle \(= 0.37393\) kw

Torque on spindle \(= 3370.9\) N-mm

Thrust force coming on spindle \(= 958.4\) N

Hence total power \(= 0.10818 + 0.2066 + 0.37393\)

\(= 0.68871\) kw

By considering 80% efficiency of whole gearbox,

Total power required \(P = 0.68871 / 0.70 = 0.9838\) kw \(\approx 1.31\) hp

So, we selected 2 hp motor.

6. SPEED CALCULATION

For Ø 8 hole two stage gear is designed.

\(i' = \text{total transmission ratio}\)
\[ i' = \frac{\text{input speed}}{\text{output speed}} = \frac{2800}{1671} = 1.7235 \]

\[ i = \text{speed reduction at each stage, for two stage} i = \sqrt{i} = 1.3128 \]

Speed of intermediate shaft = (2880/1.3128) = 2193.78 rpm

Speed of output shaft = (2193.78/1.3128) = 1671.06 rpm

From P.S.G design data book, for speed ratio of 1.3128 \( Z_p = 38 \) and \( Z_g = 50 \)

For Ø3 hole single stage gear is designed so, \[ i = \frac{\text{input speed}}{\text{output speed}} = \frac{2800}{4244} = 0.6788 \]

From P.S.G design data book, for speed ratio of 0.6788 \( Z_p = 26 \) and \( Z_g = 38 \)

For Ø12 hole we selected, for two stages \( Z_p = 38 \) and \( Z_g = 50 \) and \( Z_p = 28 \) and \( Z_g = 44 \)

### 7. MODULE CALCULATION

\[ \text{kw} = 1.492 \text{ kw}, S_u = 11157 \text{ MPa}, f_s = 1.5, C_s = 1, n_p = 2188 \text{ rpm} \]

For 2\text{nd} gear pair of 38 & 50, assume pitch line velocity = 5m/s so \[ C_v = \frac{33}{3 + v} = 0.375 \]

\[ m = \left( \frac{60 \times 10^6 \times \text{(kw)}}{\times (C_v) \times f_s \times d_z} \right)^{1/3} \]

\[ m = 0.975 \text{ & 1 mm} \]

Calculation of bending strength

\[ S_b = m \times b \times \sigma_b \times y \]

\[ = 1 \times 10 \times \frac{11157}{3} \times 0.383 \text{ ................. (Lewis form factor for 38 teeth)} \]

\[ = 1477.103 \text{ N} \]

Tangential load on gear \( P_t = 342.72 \text{ N}, \) Pitch line velocity = 4.3534 m/s, \[ C_v = \frac{8}{6 + v} = 0.5795 \]

\[ \text{Fos} = \frac{S_b}{P_{eff}} = \frac{1477.103}{591.4} = 2.49 \]

Dynamic load on gear

\[ P_d = \frac{\text{stress} \times x \times y \times z \times \omega \times C_p \times r_x \times r_y \times r_z}{2530 \times \sqrt{1 + 2}} = 96.2 \text{ N .... (grade 6)} \]

\[ P_{eff} = C_x \times P_t + P_d = 1 \times 342.72 + 96.2 = 438.88 \text{ N} \]

\[ \text{Fos} = \frac{S_b}{P_{eff}} = 3.36 \text{ hence required gear pair is safe} \]

Required BHN

\[ S_w = P_{eff} \times \text{fos} = 438.88 \times 1.5 = 658.32 \text{ N} \]

\[ Q = \frac{2 \times Z_g \times 2 \times Z_p}{Z_g + Z_p} = \frac{50 \times 38}{50 + 38} = 1.1363 \]

\[ S_w = b \times Q \times d_z \times k \]

\[ 658.32 = 10 \times 1.1363 \times 38 \times 0.16 \left( \frac{\text{BHN}}{100} \right)^2 \]

BHN = 308.68 Material for gear En 353

<table>
<thead>
<tr>
<th>DIA 3mm</th>
<th>GEAR</th>
<th>PC DIA</th>
<th>TEETH</th>
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**Table 1: Gear Information**

### 8. CONCLUSION

By using multi spindle drilling head productivity will increase. The improved productivity can be understood in various perspectives. One of which is the level of rejection in older method was higher than the new method, due to which the cost of rejection was reduced.
REFERENCES


BIOGRAPHIES

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