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

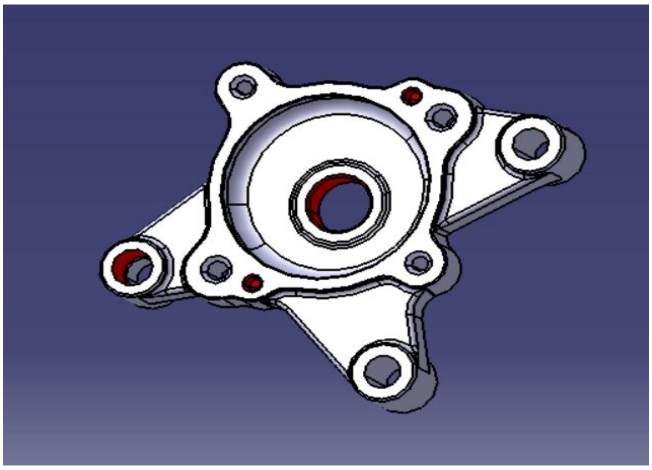

Fig -1: 3-D view of part is shown in above

Red colour indicate holes to be drilled.

4. DESIGN

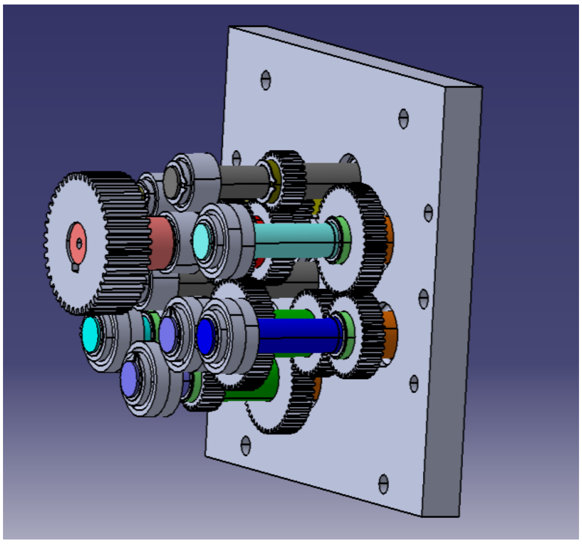

Fig-2: Three dimensional configuration diagram of Gearbox

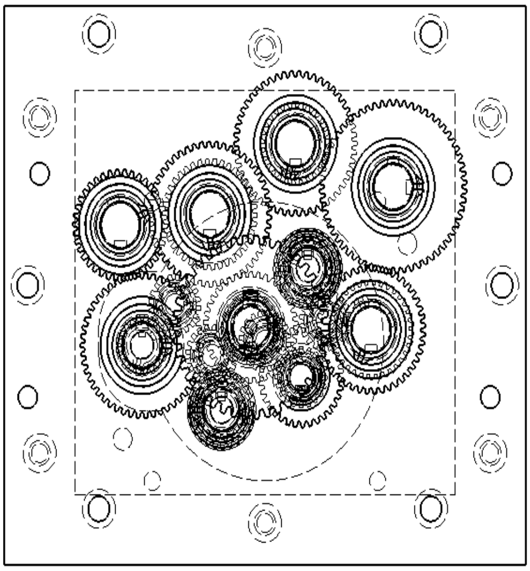

Fig-3: Two Dimensional configuration diagram of Gearbox

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 ×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,

$T_h=1.16\times k\times d\times(100\times S)^{0.85}\times 9.81$ .... (From CMTI table no. 260)

$T_h=1.16\times 0.55\times 3\times(100\times 0.1)^{0.85}\times 9.81$

T_h =132.92 N

Thrust coming two spindles =2×132.92

=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= 0.15mm/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 ≈1.31hp

So, we selected 2 hp motor.

6. SPEED CALCULATION

For Ø8 hole two stage gear is designed.

i' =total transmission ratio

i' $=\frac{\text{input speed}}{\text{output speed}}=\frac{2880}{1671}=1.7235$

i =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, $i=\frac{\text{input speed}}{\text{output speed}}=\frac{2880}{4244}=0.6788$

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 CALCULAION

kw=1.492 kw, S_{ut}=11157MPa, fos =1.5, C_S =1, n_p =2188 rpm

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

$$m=\left\{\frac{60\times10^6\times(kw)\times(cs)\times fos}{\pi\times Zp\times n\times Cv\times\frac{b}{m}\times\frac{Sut}{3}\times y}\right\}^{1/3}$$

m =0.975 ≈1 mm

Calculation of bending strength

$S_b = m\times b\times\sigma_b\times y$

$=1\times10\times\frac{1157}{3}\times0.383$ ……………… (Lewis form factor for 38 teeth)

=1477.103 N

Tangential load on gear P_t =342.72 N, Pitch line velocity=4.3534m/s, $C_v=\frac{6}{6+v}=0.5795$

$Fos=\frac{S_b}{P_{eff}}=\frac{1477.103}{591.4}=2.49$

Dynamic load on gear

$P_d=\frac{e\times n_p\times z_p\times b\times r_1\times r_2}{2530\times\sqrt{r_1^2+r_2^2}}=96.2$ N ……. (grade 6)

$P_{eff}=C_s\times P_t+P_d=1\times342.72+96.2=438.88$ N

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

Required BHN

$S_w=P_{eff}\times fos=438.88\times1.5=658.32$ N

$Q=\frac{2\times Z_g}{Z_g+Z_p}=\frac{2\times50}{50+38}=1.1363$

$S_w=b\times Q\times d_p\times k$

$658.32=10\times1.1363\times38\times0.16\times\left(\frac{BHN}{100}\right)^2$

BHN=308.68 Material for gear En 353

	GEAR mm	PCD mm	TEETH	HOLE mm	SPEED rpm	OUTER DIA mm
DIA 3mm	1	38	38	Idler	2880	39
	2	26	26	Idler	4209	27
	3	26	26	Idler	4209	27
	4	20	20	Idler	4209	21
	5	20	20	3	4209	21
	6	20	20	Idler	4209	21
	7	20	20	3	4209	21
DIA 8mm	8	38	38	Idler	2880	39
	9	50	50	Idler	2188	51
	10	50	50	Idler	2188	51
	11	38	38	Idler	2188	39
	12	50	50	Idler	1663	51
	13	20	20	Idler	1663	21
	14	20	20	8	1663	21
	15	38	38	Idler	2188	39
	16	50	50	Idler	1663	51
DIA 12mm	17	28	28	Idler	1663	29
	18	44	44	Idler	1058	45
	19	32	32	Idler	1058	33
	20	32	32	Idler	1058	33
	21	20	20	Idler	1058	21
	22	20	20	12	1058	22

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.

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