4 DESIGN OF GEAR BOXES

REUIREMENTS OF A SPEED GEAR BOXES:

1. It should provide the designed series of spindle speeds.
2. It should transmit the required amount power to the spindle.
3. It should provide the smooth and silent operation of transmission.
4. It should have simple construction.
5. Mechanism of gear boxes should be easily accessible so that it is easy to carry out maintenance.

The speeds in gear boxes can be arranged in arithmetic progression (A.P.), geometric progression (G.P) and logarithmic progression (L.P).

ADVANTAGES OF GEOMETRIC PROGRESSION:

1. The speed loss minimum.
   i.e. speed loss = desired optimum speed-available speed.
2. Number of gears to be employed is minimum.
3. G.P. provides more even numbers of spindle speeds at each step.
4. The layout is comparatively compact.
5. Productivity of the machining operation .i.e surface area of the metal removed in unit time is constant in the whole speed range.

TYPES OF GEAR BOXES:

1. Sliding mesh gear box
2. Constant mesh gear box

SLIDING MESH GEAR BOX:

Sliding mesh gear boxes are commonly used in general purpose machine tools. In order to mesh gear on main shaft with appropriate gears on the spindle shaft for obtaining different speeds they are moved to the right or left. It derives its name from the fact that the meshing of gear takes place by sliding of gears on each other.

CONSTANT MESH GEAR BOX:

It derives its name from the fact that all the gears whether of the counter shaft or the main shaft are constant in mesh with each other. It is also known as silent or quite gear box. It givesquiter operation and makes gears changing easier by employing helical gears for constant mesh. In order to connect the required gear wheel by means of teeth on the side of the gear wheel, a separate sliding member is employed.

PREFERRED NUMBERS:

Preferred numbers are the conventionally rounded off values derived from geometric series. There are five basic series denoted as R5,R10,R20,R40 and R80 series. The symbol R is used as tribute to French engineer Charles renard who introduced primary numbers first.

(PSG7.19, 20)

STEP RATIO (OR) SERIES RATIO (OR) PROGRESSION RATIO (φ):

When the spindle speeds are arranged in geometric progression, then the ratio between the two adjacent speeds is known as step ratio or progression ratio.

If $N_1, N_2 \ldots\ldots N_n$ are the spindle speeds arranged in geometric progression then

$$\frac{N_2}{N_1} = \frac{N_3}{N_2} = \frac{N_4}{N_3} \ldots\ldots \frac{N_n}{N_{n-1}} = constant$$

If n is the number of steps of speed, then

$$\frac{N_n}{N_1} = \phi^{(n-1)}$$

Or

$$\frac{N_{max}}{N_{min}} = \phi^{(n-1)}$$

STRUCTURAL FORMULA:

Let n- number of speeds available at the spindle

$P_1, P_2, P_3 \ldots$ = Stage numbers in the gear box

$X_1, X_2, X_3 \ldots$= Characteristic of the stage

$$n = P_1(X_1).P_2(X_2).P_3(X_3).P_4(X_4)$$

Where X_1=1 , X_2=P_1 , X3=$P_1.P_2$, X_4=$P_1.P_2.P_3$

Example .4.1. Find the progression ratio for a speed gear box having speeds between 100 and 355 rpm. Also find the spindle speeds.

1. Progression ratio

$$\frac{N_{max}}{N_{min}} = \phi^{(n-1)}\,; \qquad \frac{355}{100} = \phi^{12-1}\,;\ \phi = 1.122$$

Since the calculated ϕ is a standard step ratio for R20 series, therefore spindle speeds from R20 series

100,112,125,140,160,180,200,224,250,355

Example .4.2.select spindle speeds for 9 speed gear box, between 80 rpm and 1285 rpm.

Given:

n= 8

N_{min} = 80rpm

N_{max}=1285 rpm

$$\frac{N_{max}}{N_{min}} = \phi^{(n-1)}\,; \qquad \frac{1285}{80} = \phi^{9-1}\,;\ \phi = 1.415$$

We find $\phi = 1.415$ is not a standard ratio. So let us find out whether multiples of standard ratio 1.12 or 1.06 come close to 1.415.

1.12x (1.12x1.12) = 1.405 (skip 2 speeds)

So $\phi = 1.12$ satisfies the requirement. Therefore, the spindle speeds from R20 series, skipping 2 speeds are given by

80,112,160,224,315,450,630,900 and 1250 rpm

Alternate solution;

1.06x (1.06x1.06x1.06x1.06x1.06) = 1.418 (skip 5 speeds)

So $\phi = 1.06$ also satisfies the requirement. Therefore, the spindle speeds from R40 series, skipping 5 speeds are given by

80,112,160,224,315,450,630,900 and 1250 rpm

RAY DIAGRAM OR SPEED DIAGRAM:

The ray diagram is a graphical representation of the drive arrangements in general form. In other words ray diagram is a graphical representation of the structural formula.

It provides the following data on the drive:

1. The number of stages arranged (A stage is a set of gear trains arranged on two consecutive shafts)
2. The number of speeds in each stage.
3. The order of kinematic arrangements of the stages.
4. The specific values of all transmission ratios in the drive.
5. The total number of speeds available at the spindle.

DESIGN PROCEDURE:

1. Material selection for gears.
2. Find out the progression ratio (or) speed ratio φ
$$\phi = \left[\frac{N_{max}}{N_{min}}\right]^{\frac{1}{n-1}}$$
3. Draw the speed diagrams for which the number of shafts are selected based on the gear ratio which should not be more than 4 in a single step. The spindle speeds of intermediate shaft should be marked on them.
4. Draw the kinematic arrangement according to the speed diagram.
5. Compute the minimum centre distance between the shafts based on the surface compressive stress considering the worst condition (i.e. maximum power and lowest speed condition). Usually the determination of centre distance should be started from the spindle shaft and the design is proceeded to other shafts successively and finally to the motor shaft.
6. Calculate the minimum module based on design bending stress and standardize it.
7. Using the same module, find out the number of teeth of all gears for that centre distance. It should be remembered that the total number of teeth of engaging pair is equal for the same module and same distance. (PSG 8.6 to 8.12)
8. Find out the teeth of other gears.
9. Calculate actual speeds.
10. Design the other elements of the gear box such as shafts, keys, bearings and gear changing levers etc, and then draw the arrangement of the gear box neatly.

Example.4.1.the minimum and maximum speed of a six speed gear box are to be 160 and 500 rpm. Construct the kinematic arrangement and the ray diagram of the gear box.

Given:

n=6

N_{min} =160rpm

N_{max}=500 rpm

$$\phi = \left[\frac{N_{max}}{N_{min}}\right]^{\frac{1}{n-1}} = \left[\frac{500}{160}\right]^{\frac{1}{6-1}}; \phi = 1.256$$

We find $\phi = 1.256$ is not a standard ratio. So let us find out whether multiples of standard ratio 1.12 or 1.06 come close to 1.256.

We can write 1.12x1.12 =1.254 …(skip one speed)

so $\phi = 1.12$ satisfies the requirement. Therefore the spindle speeds from R20 series skipping one speed, are given by

160,200,250,315,400 and 500rpm.

STRUCTURAL FORMULA:

For six speeds , the preferred formula =3(1) 2(3)

Ray diagram:

Procedure:

- Since there are three shafts in the kinematic layout, draw 3 vertical equidistant lines to represent shafts.
- Since there are six spindle speeds. Draw six horizontal lines to represent speeds. Then mark the speeds on the horizontal lines.
- From the structural formula, it is clear that there are two stages. In the second stage i.e., in2 (3),2 represents the number of speeds available in a stage and (3) represents the steps or intervals between those two speeds.
- Locate the first point A on the lowest speed i.e., at 160rpm, on the last shaft. After 3 steps above, locate the second point B at 315 rpm. These two points A and B are the two output speeds.
- To locate the input point from the preceding shaft (i.e,shaft 2), the following requirements should be met. That is,

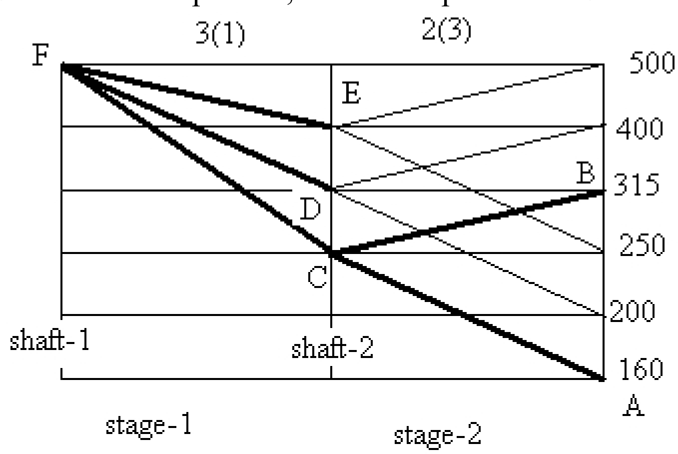
$$\frac{N_{min}}{N_{input}} \geq \frac{1}{4} \ and \frac{N_{max}}{N_{input}} \leq 2$$

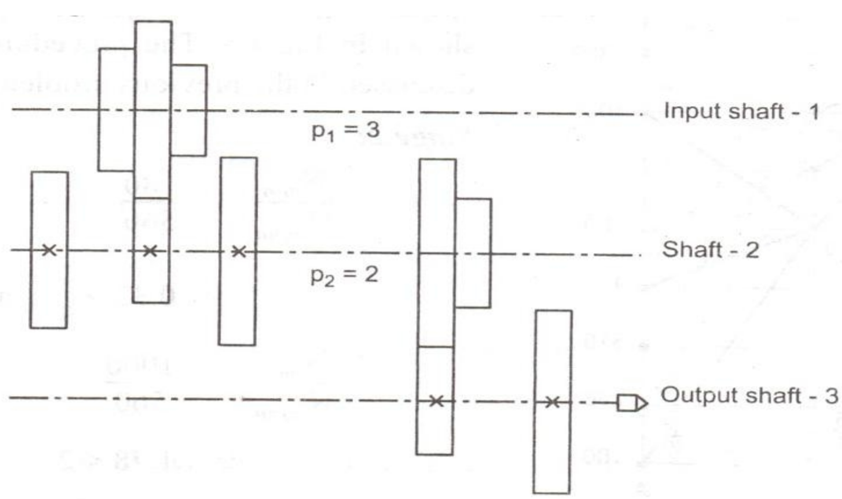
Locate point C at the input speed of 250 rpm

At point C we get

$$\frac{N_{min}}{N_{input}} = \frac{160}{250} \geq \frac{1}{4} \; and \frac{N_{max}}{N_{input}} = \frac{315}{250} \leq 2$$

- In the first stage, i.e., in 3(1), 3 represent the number of speeds available in this stage and (1) represents the step between those speeds. The lowest speed is at C, which is already located. Now locate points D and E on the 2nd shaft, above point C, in a single step interval. For these three output speeds in the first stage, the input should be from shaft1.
- Input speed can be located anywhere on shaft 1 satisfying the ratio requirements. In this case, the point F is located at 500 rpm.
- In the second stage, we find input speed at C gives two output speeds at A and B. similarly, input speeds at D and E should give two output speeds. That is from point D raw lines parallel to CA and CB. Then from point E, draw lines parallel to CA and CB.





Example.4.4.A nine speed gear box , used as a head stock gear box for a turret lathe, is to provide a speed range of 180 rpm to 1800 rpm. Using atandard step ratio draw the speed diagram, and kinematic layout.

Given:

n=9

N_{min} =180rpm

N_{max}=1800 rpm

$$\phi = \left[\frac{N_{max}}{N_{min}}\right]^{\frac{1}{n-1}} = \left[\frac{180}{1800}\right]^{\frac{1}{6-1}}; \phi = 1.333$$

We find $\phi = 1.333$ is not a standard ratio. So let us find out whether multiples of standard ratio 1.12 or 1.06 come close to 1.333.

1.12x 1.12 = 1.2544 and 1.12x1.12x1.12=1.405

1.06x (1.06x1.06x1.06x1.06) =1.338 (skip 4 speeds)

So $\phi = 1.06$ satisfies the requirement. Therefore, the spindle speeds from R40 series, skipping 4 speeds are given by

180,236,315,425,560,760,1000,1320 and 1800 rpm

Structural formula =3(1) 3(3)

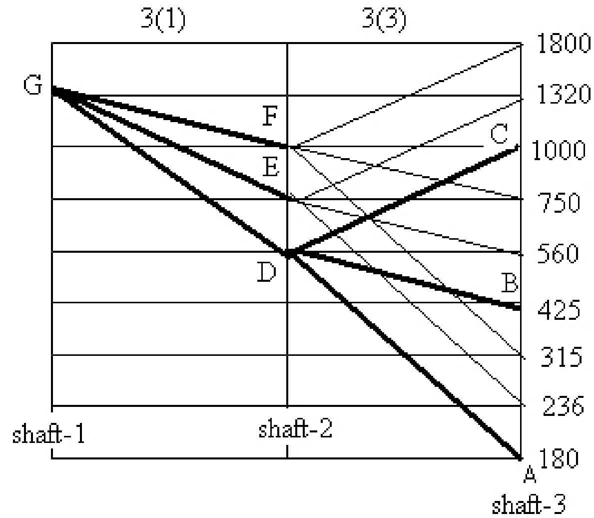
1st stage 2nd stage

For stage-2

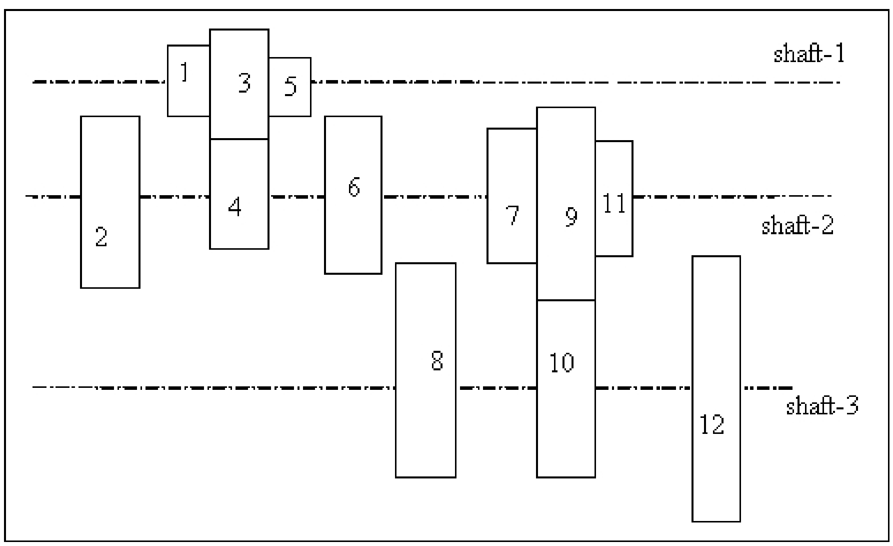
$$\frac{N_{min}}{N_{input}} = \frac{180}{560} = 0.32 > \frac{1}{4}$$

$$\frac{N_{max}}{N_{input}} = \frac{1000}{560} = 1.78 < 2$$

Ray diagram:



Kinematic arrangement:



Example.4.4. Design the layout of a 12 speed gear box for a lathe the minimum and maximum speeds are 100 rpm and 1200 rpm. Power is 5kw from 1440 rpm induction motor. Construct a speed diagram using a standard speed ratio. Calculate the number of teeth in each gear wheel and sketch the arrangement of gear box.

Given:

P =5KW

N=1440 rpm

N_{max}=1200 rpm

N_{min}=100 rpm

N=12

Solution:

1. Material selection for gears:
   Let the material for all mating gears is 40Ni2Cr1Mo28 steel
   $[\sigma_c]$ =11000 kgf/cm^2
   $[\sigma_b]$ =4000 kgf/cm^2
2. Progression ratio:

$$\phi = \left[\frac{N_{max}}{N_{min}}\right]^{\frac{1}{n-1}} = \left[\frac{1200}{100}\right]^{\frac{1}{12-1}} = 1.2535$$

   Nearest progression ratio 1.25 i.e R10 series **(psg7.20)**
   Now the twelve speeds are 100,125,160,200,250,315,400,500,630,800,1000,1250 rpm
   Let the arrangement of 12 speeds be =3(1)2(3)2(6)
   No of shafts required = 4

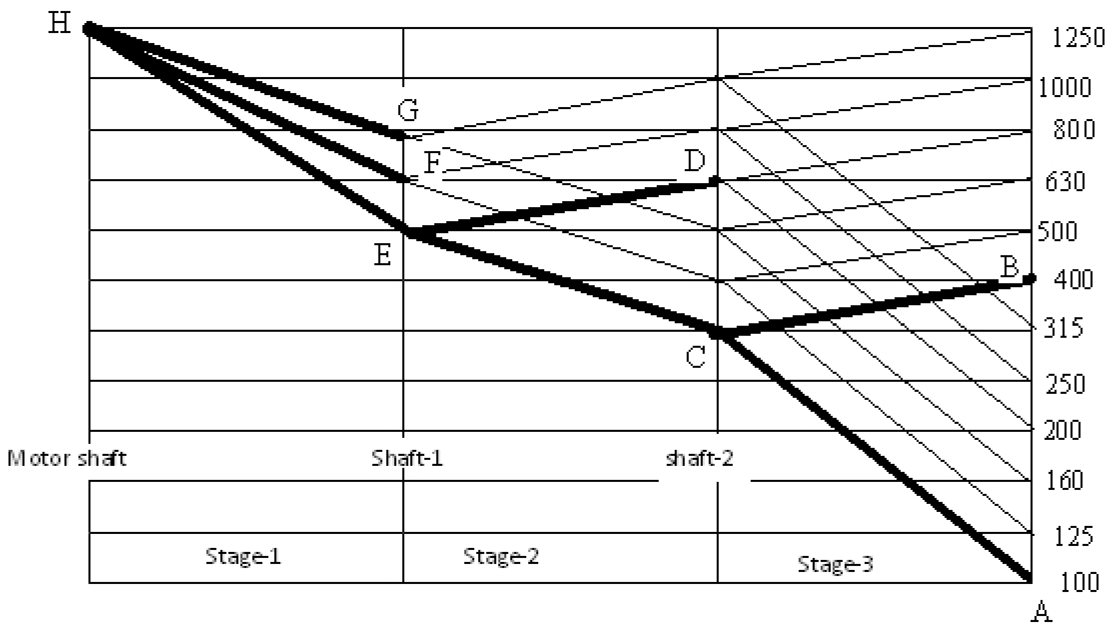
3. Speed diagram or ray diagram:
   Stage-1

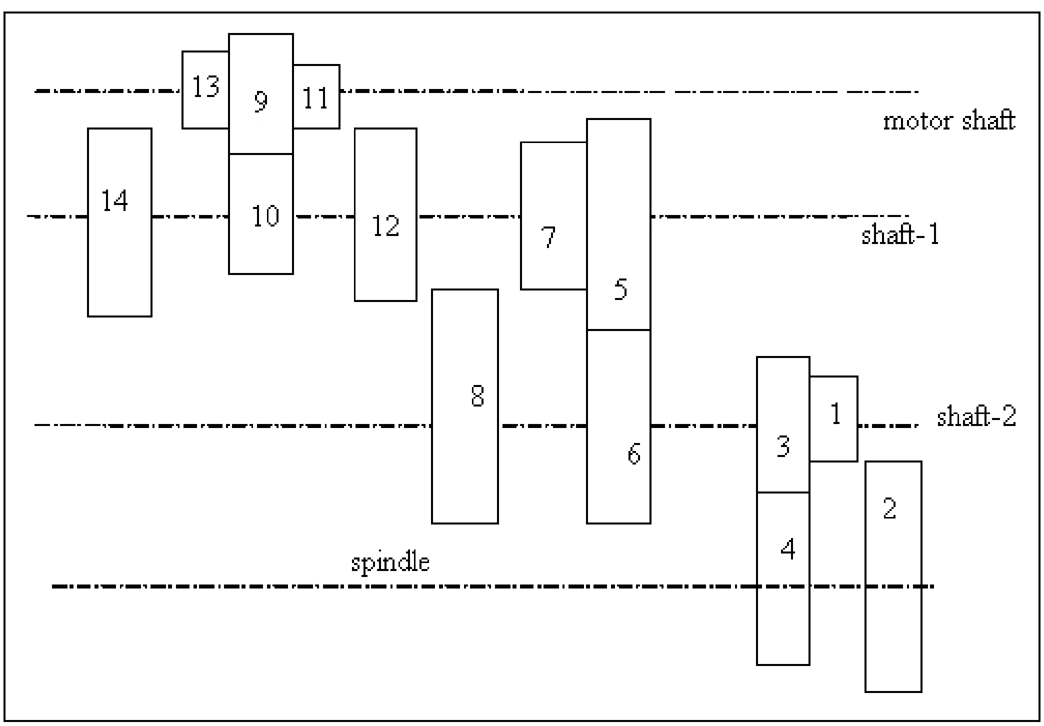
$$\frac{n_{min}}{n_{input}} \geq \frac{1}{4} \ and \ \frac{n_{max}}{n_{input}} \leq 2$$
$$\frac{100}{250} \geq \frac{1}{4} \ and \ \frac{400}{250} \leq 2$$
$$0.4 \geq \frac{1}{4}\ (0.25)\ and\ 1.6 \leq 2$$

   Stage-2

$$\frac{n_{min}}{n_{input}} \geq \frac{1}{4} \ and \ \frac{n_{max}}{n_{input}} \leq 2$$
$$\frac{315}{630} \geq \frac{1}{4} \ and \ \frac{630}{500} \leq 2$$
$$0.5 \geq \frac{1}{4}\ (0.25)\ and\ 1.26 \leq 2$$

4. Ray diagram and Kinematic arrangements:





5. MINIMUM CENTRE DISTANCE

Minimum centre distance based on the surface compressive strength

$$a \geq (i+1)\left[\left\{\frac{0.74}{[\sigma_c]}\right\}^2 \frac{E[M_t]}{i\psi}\right]^{1/3}$$ **(PSG 8.13)**

E=young's modulus = $2.1 x 10^6$ Kgf/cm^2 **(PSG 8.14)**

$[\sigma_c]$= 11000 Kgf/cm^2 (Minimum value)

i= 3.15

ψ = b/ a = 0.3 (assumed) **(PSG 8.14) table 10**

$[M_t]$ = torque transmitted by pinion=

97420x$\frac{KW}{n}$xk.k_d =97420x5/315 x1.3=2010 kgf-cm **(PSG 8.15)**

$$a \geq (3.15+1)\left[\left\{\frac{0.74}{11000}\right\}^2 \frac{2.15x10^6x2010}{2.5x0.3}\right]^{1/3}$$ =12.306 cm.

MINIMUM MODULE

$$m \geq 1.26\left[\frac{[M_t]}{[\sigma_b]\psi_m Z_1 y}\right]^{1/3}$$ **(PSG 8.13a)**

$[M_t]$ = 2010 kgf-cm

$[\sigma_b]$ = 4000 kgf/cm^2

Ψ_m=b/m = 10 (assumed) **(PSG 8.14)**

Z_1=20 (assumed)

y = 0.389 (corresponding to z_1=20) **(PSG 8.18)**

$$m \geq 1.26\left[\frac{2010}{4000X10X20X0.389}\right]^{1/3} \geq 0.2346cm \geq 2.3\ mm$$

Next standard module 'm'=3 mm **(PSG 8.2)**

CORRECT THE NUMBER OF TEETH

Number of teeth on pinion z_1= $\frac{2a}{m(i+1)}$ = 2x12.3/ 0.3(3.15+1) = 19.75 ≈ 20 **(PSG 8.22)**

z_2=i x z_1 = 3.15 x 20 = 63 teeth

FINAL CENTRE DISTANCE

$$a = \frac{m}{2}(z_1 + z_2) = \frac{0.3}{2}(20 + 63) = 12.46cm \geq [12.3cm] \therefore o.k$$

$$z_1 + z_2 = 20 + 63 = 83$$

Since the centre distance is same, the number of teeth of engaging pair is equal

i.e. $z_3 + z_4 = 83$

Gear ratio between z_3 and z_4

$$\frac{z_4}{z_3} = 1.26$$

Assume $z_4 = 46 z_3 = 37$

CENTRE DISTANCE BETWEEN SHAFT-2 AND SHAFT-1

a $\geq (i+1)\left[\left\{\frac{0.74}{[\sigma_c]}\right\}^2 \frac{E[M_t]}{i\psi}\right]^{1/3}$ **(PSG 8.13)**

E=young's modulus = 2.1×10^6 Kgf/cm^2 **(PSG 8.14)**

$[\sigma_c]$= 11000 Kgf/cm^2 (Minimum value)

i= 3.15

ψ = b/ a = 0.3 (assumed) **(PSG 8.14) table 10**

$[M_t]$ = torque transmitted by pinion

$=97420 \text{x} \frac{KW}{n} \text{x} k.k_d = 97420 \text{x} \frac{5}{500} \text{x} 1.3 = 1267$ kgf-cm **(PSG 8.15)**

$$i = \frac{500}{315} = 1.6$$

$$a \geq (1.6+1)\left[\left\{\frac{0.74}{11000}\right\}^2 \frac{2.15x10^6x1267}{1.6x0.3}\right]^{1/3} = 7.7\text{cm.}$$

MINIMUM MODULE

$$m \geq 1.26\left[\frac{[M_t]}{[\sigma_b]\psi_m Z_1 y}\right]^{1/3}$$ **(PSG 8.13a)**

$[M_t]$ = 1267 kgf-cm

$[\sigma_b]$ = 4000 kgf/cm^2

Ψ_m=b/m = 10 (assumed) **(PSG 8.14)**

Z_1=20 (assumed)

y = 0.389 (corresponding to z_1=20) **(PSG 8.18)**

$$m \geq 1.26\left[\frac{1267}{4000X10X20X0.389}\right]^{1/3} \geq 0.201cm \geq 2.01\ mm$$

Next standard module 'm'=3 mm **(PSG 8.2)**

CORRECT THE NUMBER OF TEETH

Number of teeth on pinion $z_5 = \frac{2a}{m(i+1)} = \frac{2x7.7}{0.3(1.6+1)} = 19.74 \approx 20$ **(PSG 8.22)**

Say z_5=20 teeth

Z_6=i x z_5 = 1.6 x 20 = 32 teeth

$$a = \frac{m}{2}(z_5 + z_6) = \frac{0.3}{2}(20 + 32) = 7.8cm \quad \geq [7.7cm] \therefore o.k$$

$$z_7 + z_8 = z_5 + z_6 = 20 + 32 = 52$$

$$\frac{z_7}{z_8} = \frac{N_8}{N_7} = \frac{500}{800} = 0.63$$

Assume $z_7 = 20 z_8 = 32$

CENTRE DISTANCE BETWEEN SHAFT-1 AND MOTOR SHAFT:

a $\geq (i+1)\left[\left\{\frac{0.74}{[\sigma_c]}\right\}^2 \frac{E[M_t]}{i\psi}\right]^{1/3}$ **(PSG 8.13)**

E=young's modulus = 2.1x10^6 Kgf/cm^2 **(PSG 8.14)**

$[\sigma_c]$= 11000 Kgf/cm^2 (Minimum value) i= 3.15

ψ = b/ a = 0.3 (assumed) **(PSG 8.14) table 10**

$[M_t]$ = torque transmitted by pinion

$=97420x\frac{KW}{n}xk.k_d = 97420x\frac{5}{1440}x1.3=440$ kgf-cm **(PSG 8.15)**

$$i = \frac{1440}{500} = 2.88$$

$$a \geq (2.88+1)\left[\left\{\frac{0.74}{11000}\right\}^2 \frac{2.15x10^6x440}{2.88x0.3}\right]^{1/3} = 6.61cm.$$

MINIMUM MODULE

$$m \geq 1.26\left[\frac{[M_t]}{[\sigma_b]\psi_m Z_1 y}\right]^{1/3}$$ **(PSG 8.13a)**

$[M_t]$ = 440 kgf-cm

$[\sigma_b]$ = 4000 kgf/cm^2

Ψ_m=b/m = 10 (assumed) **(PSG 8.14)**

Z_1=20 (assumed)

y = 0.389 (corresponding to z_1=20) **(PSG 8.18)**

$$m \geq 1.26\left[\frac{440}{4000X10X20X0.389}\right]^{1/3} \geq 0.14cm \geq 1.4\ mm$$

Next standard module 'm'=1.5 mm **(PSG 8.2)**

CORRECT THE NUMBER OF TEETH

Number of teeth on pinion $z_9 = \frac{2a}{m(i+1)} = \frac{2x6.61}{0.15(2.88+1)} = 22.7 \approx 24$ **(PSG 8.22)**

Say z_9=24 teeth

Z_{10}=i x z_9 = 2.88 x24 = 70 teeth

$$a = \frac{m}{2}(z_9 + z_{10}) = \frac{0.15}{2}(24+70) = 7.0cm \geq [7.7cm] \therefore o.k$$

$$z_9 + z_{10} = z_{11} + z_{12} = z_{13} + z_{14} = 94$$

$$\frac{z_{11}}{z_{12}} = 2.29$$

Assume $z_{11} = 65 z_{12} = 29$

Assume $z_{13} = 50 z_{14} = 44$

$$\frac{z_{13}}{z_{14}} = 1.15$$

FACE WIDTH

Face width b = ψa = 0.3 x7 =2.1cm

Or

b = ψ_mm = 10x 0.15 = 1.5cm

for worst case conditions

Assume

b =2.1 cm a=7 cm

The induced compressive stress

$$\sigma_c = 0.74 \left\{\frac{i+1}{a}\right\} \left[\frac{(i+1)}{i.b} E[M_t]\right]^{1/2}$$ **(PSG 8.16)**

$$= 0.74 \left\{\frac{2.88+1}{7}\right\} \left[\frac{(2.88+1)}{2.88x2.1} 2.15x10^6 x440\right]^{1/2}$$ =10105 kgf/cm^2< 11000 kgf/cm^2

The induced bending stress

$$\sigma_b = \frac{(i+1)[M_t]}{a.m.b.y} = \frac{(2.88+1)x440}{7x2.1x0.15x0.389}$$ =1990 kgf/cm^2< [σ_b]=4000 kgf/cm^2 **(PSG 8.13)**

Since the induced stresses for even the lowest parameters are less than their allowable values our design is correct.

Therefore centre distance between spindle shaft and shaft -2 =11.3cm

Centre distance between shaft-2 and shaft-1 = 9 cm

Centre distance between shaft-1 and motor shaft = 7.0 cm

NUMBER OF TEETH OF VARIOUS GEARS:

Number of teeth	Gear ratio
$Z_1 = 20, Z_2 = 63$	3.15
$Z_3 = 37, Z_4 = 46$	1.26
$Z_5 = 20, Z_6 = 32$	1.6
$Z_7 = 20, Z_8 = 32$	0.6
$Z_9 = 24, Z_{10} = 70$	2.91
$Z_{11} = 65, Z_{12} = 29$	2.25
$Z_{13} = 50, Z_{14} = 44$	1.15

Actual speeds for different output shafts

Motor speed N= 1440 rpm

Speeds for shaft-I

$$Y_1 = \frac{1440}{\left(\frac{70}{24}\right)} = 493.7\ rpm$$

$$Y_2 = \frac{1440}{\left(\frac{65}{29}\right)} = 640\ rpm$$

$$Y_3 = \frac{1440}{\left(\frac{50}{44}\right)} = 1252\ rpm$$

Speeds for shaft-II

$$X_1 = \frac{493.7}{\left(\frac{32}{20}\right)} = 309\ rpm$$

$$X_2 = \frac{640}{\left(\frac{32}{20}\right)} = 822\ rpm$$

$$X_3 = \frac{1252}{\left(\frac{32}{20}\right)} = 782.5\,rpm$$

Ex. A machine tool gear box is to have 12 speeds, with output speeds ranging from 63 rpm to 2800 rpm. Draw the speed diagrams for 2x2x3, 3x2x2, 3x4 and 4x3 schemes, among these schemes which is better, why?

Two marks questions

1. What are the points to be considered while designing a sliding mesh type of multi-speed gear box?

i) The transmission ratio in a gear box is limited by ¼ < i < 2

ii) Speed ratio of any stage should not be greater than 8.

2. Which type of gear is used in constant mesh gear box? Justify.

Helical gears are used in constant mesh gear boxes to provide quieter and smooth operation.

3. Compare sliding mesh and synchromesh gear box.

sliding mesh gear box: It derives its name from the fact that the meshing of the gears take place by sliding of gears on each other. With sliding mesh gear box, double de-clutching is necessary to bring the two sets of dog teeth to the same speed so that they can be slid into engagement quietly.

synchromesh gear box: To eliminate the need to de-clutch, the synchromesh gear box was introduced. The basic gear box is laid out in the same manner as the constant mesh, but with the addition of a cone clutch fitted between the dog and gear members.

4. Where is multi-speed gear boxes employed?

They are employed wherever the variable spindle speeds are necessary.

5. Name the series in which speeds are arranged in multi-speed gear boxes.

Basic series of preferred numbers are R5, R10, R20, R40& R80.

6. List six standard speeds starting from 18 rpm with a step ratio 1.4.

For the step ratio Φ = 1.4, the R20 series, the standard speeds are 18, 20, 22.4, 25, 28 & 31.5 rpm.

7. Sketch the kinematic layout of gears for 3 speeds between two shafts.

Refer pg.no: 9.11 Dots by V.Jayakumar

8. Differentiate ray diagram and structural diagram.

Ray diagram is a graphical representation of the structural formula.

Structural diagram is a kinematic layout that shows the arrangement of gears in a gear box.

9. List out the basic rules to be followed for optimum gear box design.

i) The transmission ratio in a gear box is limited by ¼ < =i < 2

ii) Speed ratio of any stage should not be greater than 8.

10. What is step ratio? Name the series in which speeds of multi-speed gear box are arranged.

When the spindle speeds are arranged in geometric progression, then the ratio between the two adjacent speeds is known as speed ratio.

Basic series are R5, R10, R20& R40.

11.What situation demand use of gear boxes?

Gear boxes are required wherever the variable spindle speeds is necessary.

12.Write any two required of a speed gear box?

Gear box should provide the designed series of spindle speed.

Gear box should transmit the required amount of power to the spindle.

13.List any two methods used for changing speeds in gear boxes.

a. sliding mesh gearbox

b. constant mesh gear box

14.What are preferred numbers?[AU, MAY-06]

Preferred numbers are the conventionally rounded off values derived from geometric series. There are five basic series, denoted as R5,R10,R20,R40 andR 80series.

15.What is step ratio? [AU, MAY-10]

When the spindle speeds are arranged in geometric progression, then the ration between the two adjacent speeds is known as step ratio.

16.What does the ray diagram of gear box indicates?[AU, May- 06]

The ray diagram is a graphical representation of the drive arrangement in general form. It serves to determine the specific values of all the transmission ratios and speeds of all the shafts in the drive.

17.What is kinematic arrangement as applied to gear boxes?

The kinematic layout shows the arrangement of gears in a gear box. It also provides information like number of speeds available at each spindle and the number of stages used.

18.What is speed reducer?

Speed reducer is a gear mechanism with a constant speed ratio, to reduce the angular speed of output shaft as compared with that of input shaft.

19.State any three basic rules to be followed while designing a gear box.

a. The transmission ratio (i) in a gear box by $\frac{1}{4} <= i <= 2$.

b. For stable operation, the speed ratio of any stage should not be greater than 8 that is $N_{max}/N_{min} \leq 8$.

c. In all stages except in the first stage, $N_{max} \geq N_{input} > N_{min}$.

20. What is the function of spacers in a gear box?[AU, MAY-07]

The function of spacers is to provide the necessary distance between the gears and the bearings.

Gear box:

April/may2008

1. List six standard speeds starting from 18 rpm with a step ratio 1.4.
2. Sketch the kinematic layout of gears for 3 speeds between two shafts.
3. Sketch the arrangement of six speed gear box. The minimum and maximum speeds required are around 460 and 1400 rpm. Drive speed is 1440 rpm at 9kW. Construct speed diagram of gear box and obtain various reduction ratios. Use standard output speeds and standard step ratio. Calculate number of teeth in gear and verify whether the actual output speeds are within ± 2% of standard speeds.
4. Design the layout of a 12 speed gear box for a milling machine having an output speeds ranging from 180 to 200 rpm. Power is supplied to the gear box from a 6kw induction motor

at 1440 rpm. Choose standard step ratio and construct the speed diagram. Decide upon the various reduction ratios and number of teeth on each gear wheel. Sketch the arrangement of gear box.

Nov/dec2006

5. Draw the ray diagram of six speed gear box.
6. Design a nine speed gear box for a machine to provide speeds ranging from 100 to 1500 rpm. The input is from a motor of 5 KW at 1440 rpm. Assume alloy steel for the gear.
   Nov/dec2007
7. Differentiate ray diagram and structural diagram.
8. List out the basic rules to be followed for the optimum gear box design.
9. A machine tool gear box is to have 9 speeds. The gear box is driven by an electric motor whose shaft rotational speed is 1400 rpm. The gear box is connected to the motor by a belt drive. The maximum and minimum speeds required at the gear box output are 1000 rpm and 200 rpm respectively. Suitable speed reduction can also be provided in the belt drive. What is the step ratio and what are the values of 9 speeds? Sketch the arrangement. Obtain the number of teeth on each gear and also the actual output speeds.
10. A six speed gear box is required to provide output speeds in the range of 125 to 400 rpm with step ratio of 1.25 and transmit a power of 5 KW at 710 rpm. Draw the speed diagram and kinematic diagram. Determine the number of teeth, module, face width of all gears, assuming suitable materials for the gears. Determine the length of the gear box along the axis of the gear shaft.

May//June 2007

11. What is step ratio? Name the series in which speeds of multi-speed gear box are arranged.
12. Give some application of constant mesh gear box.
13. Design a 9 speed gear box for the following data:
    Minimum speed: 100 rpm, step ratio: 1.25, the input is from a 4 kW, 1400rpm motor. Draw the speed diagram and indicate the number of teeth on each gear in kinematic diagram.
14. Select speeds for a 12 speed gear box for a minimum speed of 160 rpm and maximum speed of 1400 rpm. Draw a kinematic arrangement of the gear box showing the number of teeth. The drive is from 5kw motor at 1440 rpm.
15. Design a 9 speed gear box to give output speeds between 280 and 1800 rpm. The input power is 5.5 KW at 1400 rpm. Draw the kinematic layout diagram and the speed diagram.Determine the number of teeth on all gears. [M/J'13]
16. Design the layout of a 12 speed gear box for a lathe. The minimum and maximum speeds are 100 and 1200 rpm. Power is 5 KW from 1440 rpm. Draw the speed and kinematic diagram. Also calculate the number of teeth on all gears. [M/J'13]

17. For a load lifting arrangement transmitting 10 KW with electric motor running at 1400 rpm, constant mesh type speed reducer is required with reduction ratio 12. Design a suitable arrangement and make a neat sketch. [N/D’12]
18. Select speeds for a 12 speed gear box for a minimum speed of 16 rpm and maximum speed of 900 rpm. Drive speed is 900 rpm. Draw speed diagram and draw kinematic arrangement of the gear box showing the number of teeth in all the gears. [N/D’12]
19. Design a sliding mesh nine speed gear box for a machine tool with speed ranging from 36 rpm to 550 rpm. Draw the speed diagram and kinematic arrangement showing number of teeth in all gears. [M/J’12]
20. An all geared headstock of a lathe requires a 12 speed gear box with minimum and maximum of 110 rpm and 1440 respectively. Draw speed diagram and show the details of number of teeth in all the gears in a kinematic layout. [M/J’12]
21. A gear box is to be designed with the following specifications: [N/D’11]
    Power=14.72 KW, number of speeds =18
    Minimum speed = 16 rpm, step ratio =1.25
    Motor speed = 1400 rpm. The 18 speeds are obtained as 2*3*3
    1. Sketch the layout of the gear box.
    2. Draw the speed diagram.
22. The minimum and maximum speed of a six speed gear box is to be 160 and 500 rpm. Construct the kinematic arrangement and the ray diagram of the gear box. Also find the number of teeth of all gears. [M/J’11]
23. Design a 12 speed gear box for an all geared headstock of a lathe. Maximum and minimum speeds are 600 rpm and 25 rpm respectively. The drive is from an electric motor giving 2.25 KW at 1440 rpm. [M/J’11]

UNIT-5 DESIGN OF CAM, CLUTCHES AND BRAKES

DESIGN OF CLUTCHES:

A clutch consists principally of two main sections that are engaged or disengaged on an intermittent basis either by manually or by some power driven devices. In clutches power transmission is achieved through (a) inter locking (b) friction (c) wedging (d) magnetic field.

According to the power transmitting method, clutches are categorized into

1. Positive clutches
2. Friction clutches
3. Cone clutches
4. Magnetic clutches

MECHANICALLY OPERATED CLUTCHES:

1. FRICTION CLUTCHES
   a. Disc or plate clutches
      1. Single plate clutches
      2. Multi plate clutches
   b. Cone clutches
   c. Centrifugal clutches
2. POSSITIVE CLUTCHES
   Jaw or claw clutches
   i. Square clutches
   ii. Spiral clutches

SINGLE PLATE CLUTCHES: