DATE

Helical Gear Milling

SHEET NO.

Objective :- To et machine a 12 DP, 73 teeth, right hand helical gear with 15° helix angle on a horizontal column and a knee type universal milling machine with a rotary disc type form gear cutter.

Apparatus :-

a) Horizontal column and knee type universal milling machine
b) 12 DP no. 2 cutter
c) Gear tools
d) Vernier caliper
e) Dial indicator
f) Cast Iron gear blank and mandrel
g) Change gears
h) Indexing head.

Theory and procedure :-

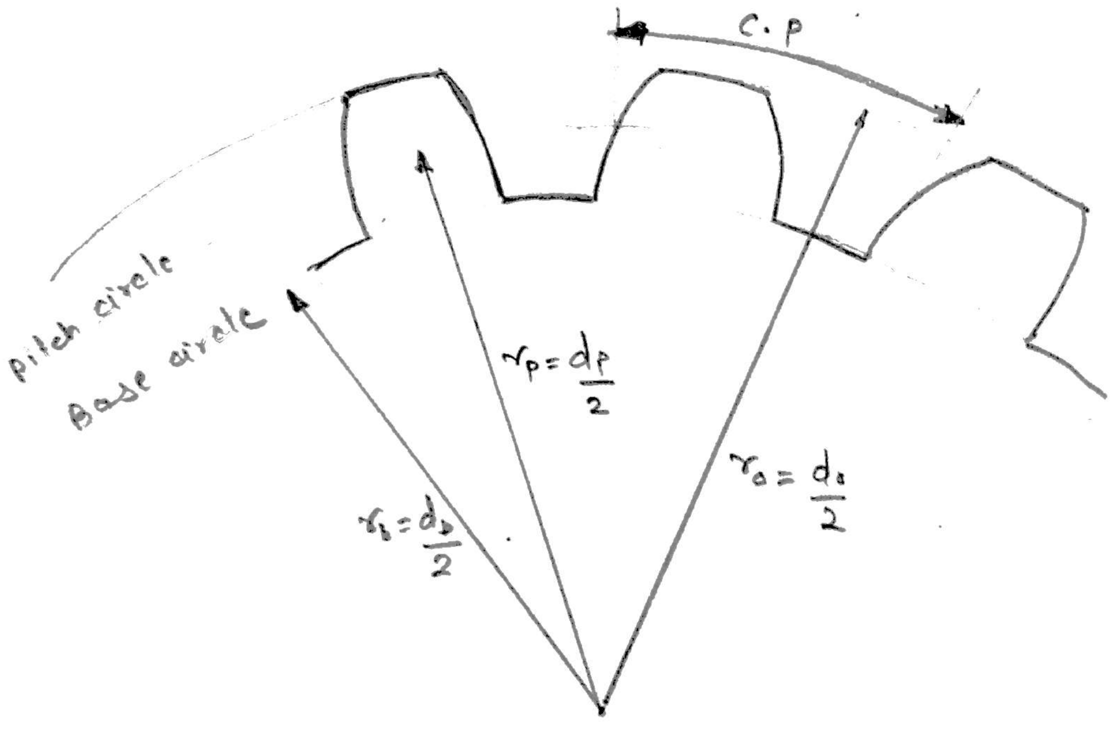
Spur gear cutting is generally made by 2 methods:-
① Gear hobbing ② Gear Shaping
The helical gear machining operation is similar to the gear shaping operation where form cutters are used to give the gear blank the form of the cutters.
The helical gear milling is thus a form cutting operation.

Gear metrology :-

Spur gear :-

Spur gears are used for connecting parallel shaft and the teeth in it may be straight (parallel to the axis of rotation) or helical.

Different parameters of a gear and their understanding



Diameter of pitch circle = d_p

Number of teeth = z

Circular pitch = C P

$\therefore C \cdot P \times z = \pi d_p$

$\Rightarrow \boxed{C \cdot P = \frac{\pi d_p}{z}}$

Parameter $\left(\frac{d_p}{z}\right)$ is known as (m) module which is the popular specification of the gear.

However, the term dimetral pitch (D.P) is also used in certain cases (especially in the FPS system)

So, $\boxed{C \cdot P = \pi m}$

Addendum = m (followed as a standard)

$\therefore$ The outer circle diameter d_o:-

$\boxed{d_o = d_p + 2m}$

$\therefore d_o = zm + 2m \Rightarrow \boxed{d_o = (z+2)\, m}$

For two gears to mesh, they must have the same module or dimetral pitch.

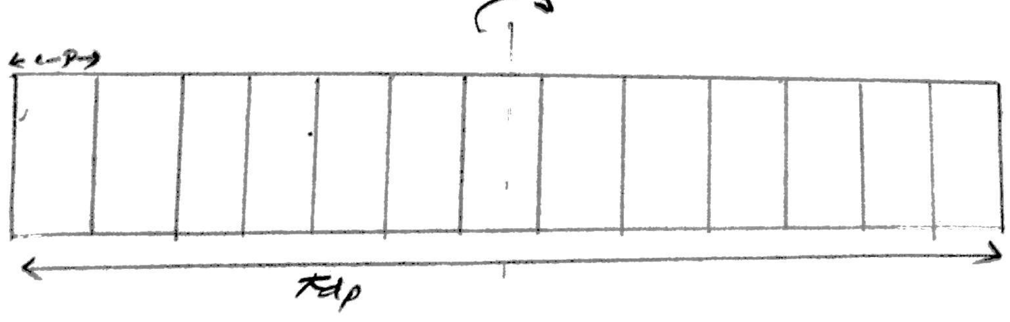
Helical gear :-

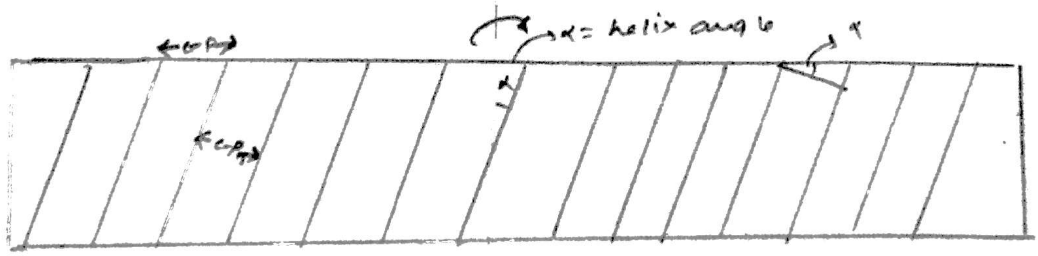
Helical gears are prefered over the spur gears for the reasons of reducing noise and improving the smoothness of the operation.

Whole spur gear tooth comes into contact with the meshed spur gear tooth. As a result, greater forces is applied which may increase the wear & tear of the spur gear. But in helical gear, tooth comes into contact gradually and hence wear and tear is reduced.

Teeth of such gears form part of helix and the normal force between the teeth is inclined to the axis of rotation.

The diagrams of spur & helical gear can be drawn as follows:-





$CP \rightarrow$ circular pitch

$CP_n \rightarrow$ Normal circular pitch for the helical gear.

From geometry, $CP_n = CP \cos\alpha$

Similarly, there are two modules defined for the helical gear, the additional being the normal module m_n.

When a particular module for a helical gear is specified it is taken as the normal module m_n.

$m_n = m \cos\alpha$

Now let us find out the few dimensions of the helical gear we are supposed to machine

D.P = 12 (in FPS units)

$$m_n = \frac{25.4 \text{ mm}}{12} = 2.117$$

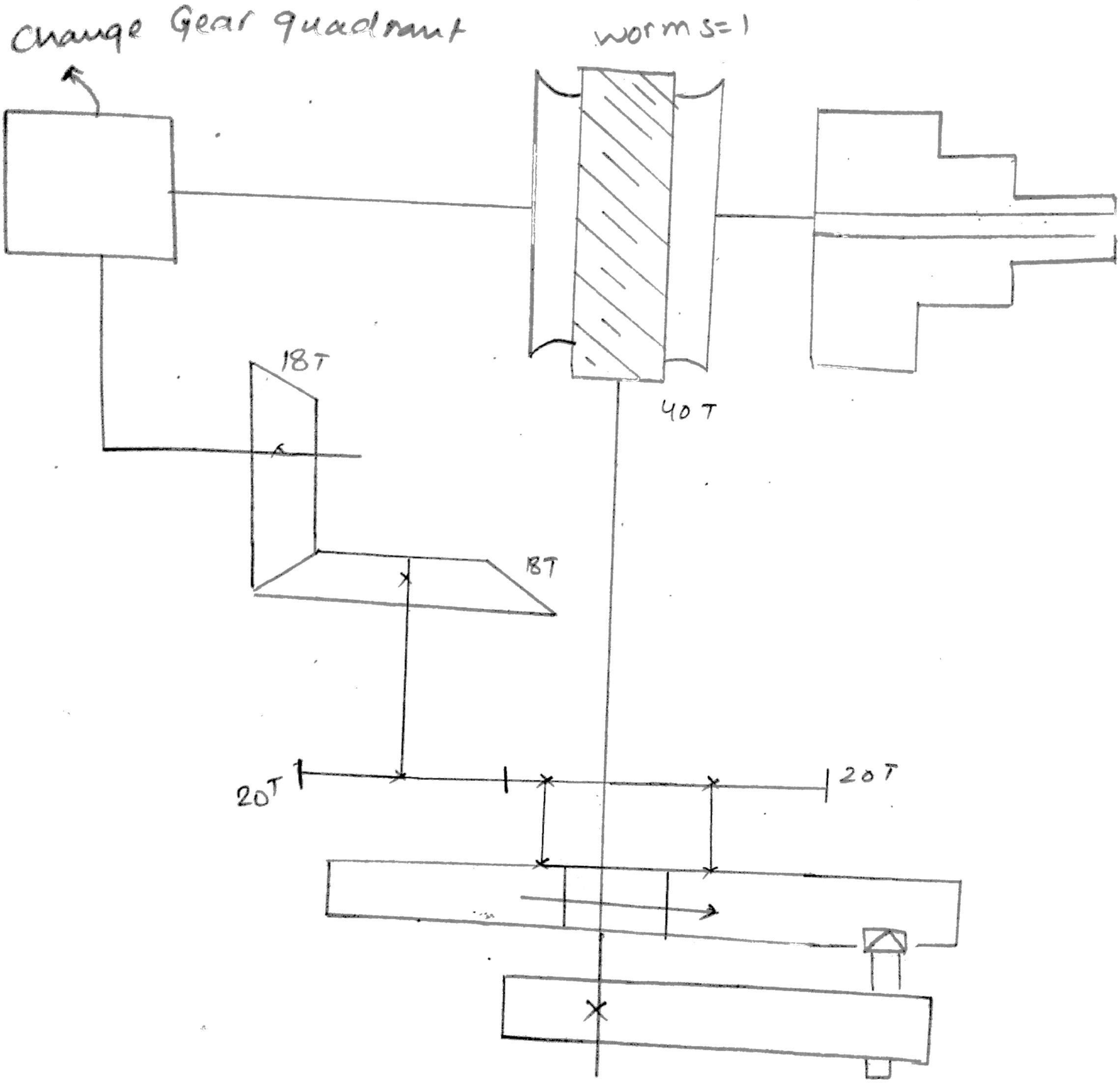
$Z = 73$, $\alpha = 15^\circ$ (helix angle)

$$d_o = (z+2)\,m$$

$$= 75 \times \frac{m_n}{\cos\alpha} = 164.376 \text{ mm}$$

$$d_p = d_o - 2m = 159.99 \text{ mm} \approx 160 \text{mm}$$

Differential indexing :-



For 1 rotation of spindle → no. of cranck rotations = 40

— " — $\frac{1}{z}$ — " — → — " — — " — = $\frac{40}{z}$

Now if suppose no. of teeth $z = 37$.

crank rotations required = $\frac{40}{37} = 1 + \frac{3}{37}$

This is achieved by giving 1 full ~~&~~ rotation to the index crank shaft and giving a rotation by 3 holes on an index plate of 37 holes.

For this purpose we can always use method of multiples like 6 holes on plate of 74 holes, such that the ratio remains same.

If suppose we want to cut $z_n = 53$.

but available no. of holes in the index plate ~~is 49~~.

Can give $Z_a = 49$.

In this case, we use differential ~~gearing~~ indexing.

The pin should move by $\frac{40}{53}$ rotations

but it is actually moved by $\frac{40}{49}$ rotations

& the index plate is moved backward by :-

$\frac{40}{49} - \frac{40}{53}$ rotation such that the relative rotation of the pin remains the required value $\frac{40}{53}$

P.R.

As, $49 < 53$

$$\frac{40}{49} > \frac{40}{53}$$

or $$\frac{40}{z_a} > \frac{40}{z_r}$$

$$\boxed{\frac{40}{z_a} = \frac{40}{z_r} + \frac{u_d}{z_r}}$$

where u_d is the gear ratio in Change gear quadrant.

$$u_d = \left(\frac{40}{z_a} - \frac{40}{z_r}\right) \times z_r$$

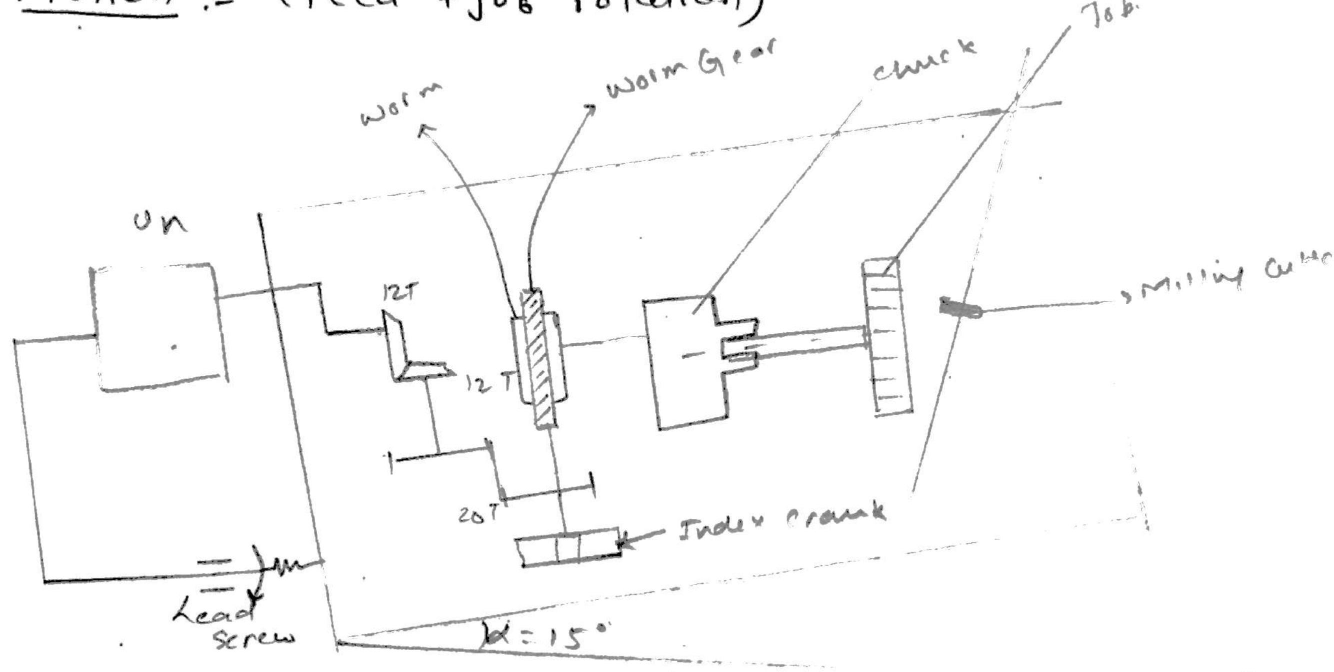
$$= \frac{z_r - z_a}{z_a} \times 40$$

For the above eg. :- $u_d = \frac{53-49}{49} \times 40$

$$= \frac{160}{49} = \frac{16 \times 10}{7 \times 7} = \frac{48}{21} \times \frac{30}{21}$$

If U_d comes out to be positive, the plate should rotate opposite to crank shaft and vise versa.

Coupled motion :- (Feed + job rotation)



The feed motion is given to the w/p by moving the entire table with the help of the lead screw. Since the helical gear has a particular pitch, the feed has to be coupled with the cutting motion, that is the rotation of the workpiece.

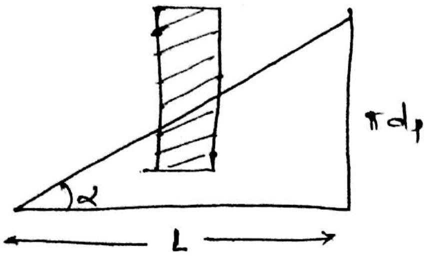
For one complete rotation of the job, the feed that has to be provided = L (Pitch of the gear)

pitch of the lead screw = 5 mm

Gear ratio of the gear chain quadrant = U_h

Worm gear no. of teeth = 40

No. of starts in worm = 1



$$\tan\alpha = \frac{\pi d_p}{L}$$

$$L = \frac{\pi d_p}{\tan\alpha} = \frac{\pi \times 160}{\tan 15^\circ}$$

$$\boxed{L = 1875.93 \text{ mm}}$$

Rotation of the shaft after gear quadrant $= \frac{L}{5} U_n$

Since the transmission ratio of the gear is 1:1,

the rotation transfereed to the worm gear $= \frac{L}{5} U_n$

Rotation of the worm $= \frac{L}{5} \times U_n \times \frac{1}{40} = 1$ rotn of w/p

$$U_n = \frac{40 \times 5}{L} = 0.1066.$$

The exact transmission ratio is impossible to obtain, given the limitation on the available standard gears with the standardized set of no. of teeth.

The closest rational no. that would be available is :- $\frac{1}{9} = 0.11$

So, we need to set the gear quadrant in such a way that we get a ratio of 1:9.

This is done by the following manner:-

$$\frac{24}{96} \times \frac{32}{72} = \frac{1}{9}.$$

Concept of Virtual no. of teeth (Z_n)

A plane normal to the element of the helical gear will intersect the pitch cylinder in the ellipse having a radius R at the end of the semi-minor axis of the ellipse. From analytical geometry we find that:-

$$R = \frac{d_p}{2\cos\psi}$$

The formation no. (virtual no.) of teeth is defined as the number of teeth in the gear of radius R.

$$Z_v = \frac{2\pi R}{C \cdot P_n} = \frac{\pi d_p}{C\, P_n \cos^2\alpha} = \frac{Z}{\cos\alpha} \cdot \frac{1}{\cos^2\alpha} = \frac{Z}{\cos^3\alpha}$$

$$\therefore \boxed{Z_v = \frac{Z}{\cos^3\alpha}}$$

This defines a virtual gear which is equivalent to a spur gear with Z_v teeth

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