DETAILS EXPLANATIONS

ME: Paper-2 (Paper-3) [Full Syllabus]

[PART : A]

1. ***In order to transmit motion, the driver and the follower may be connected by the following three types of links :***
   - ***Rigid Link :***
     A rigid link is one which does not undergo any deformation while transmitting motion. Strictly speaking, rigid links do not exist. However, as the deformation of a connecting rod, crank etc. of a reciprocating steam engine is not appreciable, they can be considered as rigid links.
   - ***Flexible Link :***
     A flexible link is one which is partly deformed in a manner not to affect the transmission of motion. For example, belts, ropes, chains and wires are flexible links and transmit tensile forces only.
   - ***Fluid Link :***
     A fluid link is one which is formed by having a fluid in a receptacle and the motion is transmitted through the fluid by pressure or compression only, as in the case of hydraulic presses, jacks and brakes.
2. It is the friction, experienced by a body, when in motion. The dynamic friction is also called kinetic friction and is less than the static friction.
3. A belt drive with an idler pulley, as shown in figure (a), is used with shafts arranged parallel and when an open belt drive cannot be used due to small angle of contact on the smaller pulley.

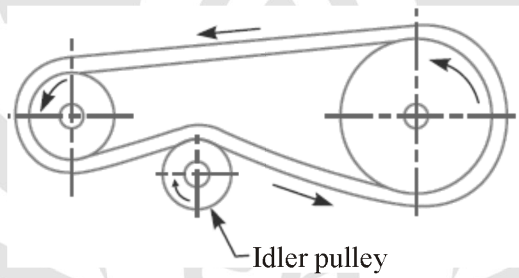


Figure (a) : Belt Drive with Single idler pulley

This type of drive is provided to obtain high velocity ratio and when the required belt tension cannot be obtained by other means.

When it is desired to transmit motion from one shaft to several shafts, all arranged in parallel, a belt drive with many idler pulleys, as shown in figure (b), may be employed.

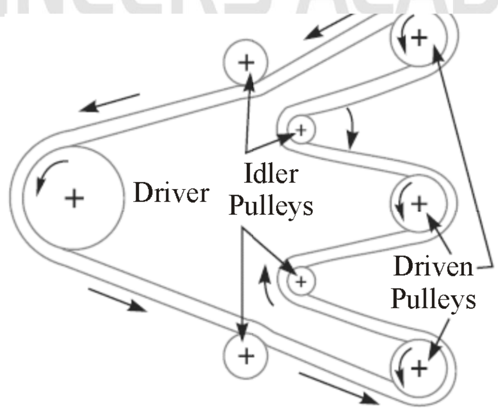


Figure (b) : Belt Drive with many idler pulley

4. When the belt passes from the slack side to the tight side, a certain portion of the belt extends and it contracts again when the belt passes from the tight side to slack side. Due to these changes of length, there is a relative motion between the belt and the pulley surfaces. This relative motion is termed as creep. The total effect of creep is to reduce slightly the speed of the driven pulley or follower. Considering creep, the velocity ratio is given by

$$\frac{N_2}{N_1} = \frac{d_1}{d_2} \times \frac{E+\sqrt{\sigma_2}}{E+\sqrt{\sigma_1}}$$

Where, σ_1 and σ_2 = Stress in the belt on the tight and slack side respectively.

and E = Young's modulus for the material of the belt.

5. It is the ratio of the pitch circle diameter in millimeters to the number of teeth. It is usually denoted by m. Mathematically,

Module, $m = \frac{D}{T}$

6. ***Ganges :***

A gauge is defined as a device for determining whether or not one or more of the dimensions of a manufactured part are with in specified limits. Gauges are also designed by tool designer in consultation with department- They are also manufactured in the tool room. Gauges are used both by inspectors and workers.

7. When a material is subjected to repeated stresses, it fails at stresses below the yield point stresses. Such type of failure of a material is known as fatigue. The failure is caused by means of a progressive crack formation which are usually fine and of microscopic size. This property is considered in designing shafts, connecting rods, springs, gears, etc.

8. It consists of heating the metal to forging temperature and then forming it into the desired shape on a spinning lathe. The parts of circular cross-section which are symmetrical about the axis of rotation, are made by this process.

9. Given : $d = 25$ mm ; $P = 2500$ N ; $p_b = 5$ N/mm^2

Lel l = Length of the sliding bearing in mm

We know that the projected area of the bearing

$$A = l \times d = l \times 25 = 25\, l \text{mm}^2$$

$\therefore$ Bearing pressure (p_b),

$$5 = \frac{P}{A} = \frac{2500}{25l} = \frac{100}{l}$$

or $$l = \frac{100}{5} = 20 \text{ mm}$$

10. The economic order quantity (EOQ) method is preferable when relatively constant independent demand exists. It is a statistical technique using averages, whereas the MRP procedure assumes known demand reflected in the master production schedule.

11. Given that $\mu = 0.4$

$D_1 = 95$

$D_2 = 82$

$D_3 = 68$

$D_4 = 70$

Forecast for the fifth month is given by

$$F_5 = \mu D_1 + \mu(1-\mu)D_2 + \mu(1-\mu)^2 D_3 + \mu(1-\mu)^3 D_4$$
$$= 73.52$$

12. By moving average, forecast for fifth year is

$$F_5 = \frac{880+870+890}{3}$$

By exponential smoothing with constant μ, forecast for fifth year is

$$F_5 = 876 + \mu(890 - 876)$$

$$\mu = \frac{2}{7}$$

13. The cost associated with the procedure for the placement of purchase orders of the inventory is called ordering cost or setup cost (O(Q)). It includes the cost of stationary, postage, telephone, traveling expenses, material handling, etc. The ordering cost is independent of the batch size of the order.

14. As 2555 units are required in 365 days, therefore, 8 days quantity is

$$\text{Reorder level} = \frac{2555}{365}\times 8 = 56$$

15. Given that

$$\mu = 60 \text{ per hour}$$
$$\lambda = 50 \text{ per hour}$$

The waiting time is calculated as

$$t_q = \frac{\lambda}{\mu(\mu-\lambda)} = \frac{50}{60-50}$$

$$= 0.083 \text{ hours} = 5 \text{ min}$$

16. It is an operation of cutting any shape from sheet metal without special tools. It is done on a nibbling machine.

17. It is the operation of cutting away excess metal in a flange or flash from a sheet metal part using suitable punch and die of press tool in press machine.

18. Chaplets are metal distance pieces inserted in a mould either to prevent shifting of mould or locate core surfaces. The distances pieces in form of chaplets are made of parent metal of which the casting is. These are placed in mould cavity suitably which positions core and to give extra support to core and mould surfaces. Its main objective is to impart good alignment of mould and core surfaces and to achieve directional solidification. When the molten metal is poured in the mould cavity, the chaplet melts and fuses itself along with molten metal during solidification and thus forms a part of the cast material.

19. It is generally used as a secondary binder to increase the hardness on baking. It is used in the form of molasses liquid and is sprayed on the cores before baking.

20. Ductility is termed as the property of a material enabling it to be drawn into wire with the application of tensile load. A ductile material must be strong and plastic. The ductility is usually measured by the terms, percentage elongation and percent reduction in area which is often used as empirical measures of ductility. The materials those possess more than 5% elongation are called as ductile materials. The ductile material commonly used in engineering practice in order of diminishing ductility are mild steel, copper, aluminium, nickel, zinc, tin and lead.

[PART : B]

21. This mechanism is mostly used in shaping and slotting machines. In this mechanism, the link CD (link 2) forming the turning pair is fixed, as shown in figure.

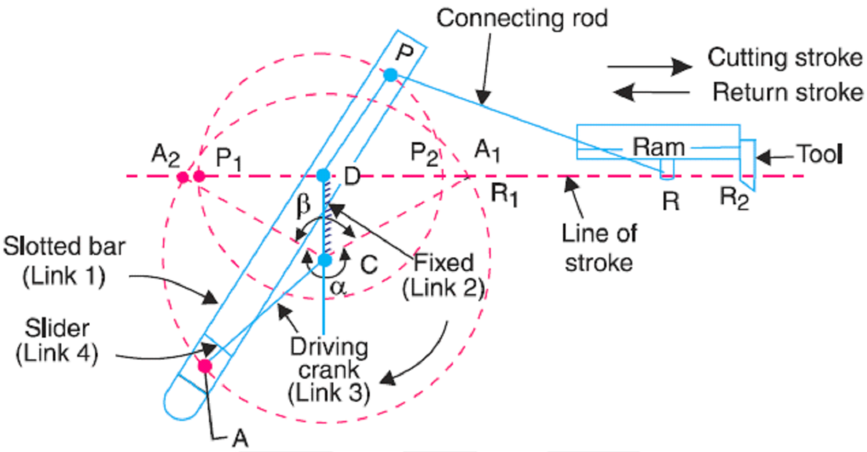


Figure : Whitworth quick return motion mechanism

The link 2 corresponds to a crank in a reciprocating steam engine. The driving crank CA (link 3) rotates at a uniform angular speed. The slider (link 4) attached to the crank pin at A slides along the slotted bar PA (link 1) which oscillates at a pivoted point D. The connecting rod PR carries the ram at R to which a cutting tool is fixed. The motion of the tool is constrained along the line RD produced, i.e. along a line passing through D and perpendicular to CD.

When the driving crank CA moves from the position CA_1 to CA_2 (or the link DP from the position DP_1 to DP_2) through an angle á in the clockwise direction, the tool moves from the left hand end of its stroke to the right hand end through a distance 2 PD.

Now when the driving crank moves from the position CA_2 to CA_1 (or the link DP from DP_2 to DP_1) through an angle â in the clockwise direction, the tool moves back from right hand end of its stroke to the left hand end.

A little consideration will show that the time taken during the left to right movement of the ram (i.e. during forward or cutting stroke) will be equal to the time taken by the driving crank to move from CA_1 to CA_2. Similarly, the time taken during the right to left movement of the ram (or during the idle or return stroke) will be equal to the time taken by the driving crank to move from CA_2 to CA_1.

Since the crank link CA rotates at uniform angular velocity therefore time taken during the cutting stroke (or forward stroke) is more than the time taken during the return stroke. In other words, the mean speed of the ram during cutting stroke is less than the mean speed during the return stroke. The ratio between the time taken during the cutting and return strokes is given by

$$\frac{\text{Time of cutting stroke}}{\text{Time of return stoke}} = \frac{\alpha}{\beta} = \frac{\alpha}{360^\circ - \alpha} \text{ or } \frac{360^\circ - \beta}{\beta}$$

22. Given :

$$W = 75 \text{ kN} = 75 \times 10^3 \text{ N}$$
$$v = 300 \text{ mm/min}$$
$$p = 6 \text{ mm}$$
$$d_0 = 40 \text{ mm}$$
$$\mu = \tan\phi = 0.1$$

We know that mean diameter of the screw,

$$d = d_0 - \frac{p}{1} = 40 - \frac{6}{2} = 37 \text{ mm} = 0.037 \text{ m}$$

and $$\tan\alpha = \frac{p}{\pi d} = \frac{6}{\pi \times 37} = 0.0516$$

∴ Force required at the circumference of the screw,

$$p = W\tan(\alpha + \phi) = W\left[\frac{\tan\alpha + \tan\phi}{1 - \tan\alpha.\tan\phi}\right]$$

$$= 75 \times 10^3\left[\frac{0.0516 + 0.1}{1 - 0.0516 \times 0.1}\right] = 11.43 \times 10^3 \text{ N}$$

and torque required to overcome friction,

$$T = P \times \frac{d}{2} = 11.43 \times 10^3 \times \frac{0.037}{2} = 211.45 \text{ N-m}$$

We know that speed of the screw,

$$N = \frac{\text{Speed of the nut}}{\text{Pitche of the screw}} = \frac{300}{6} = 50 \text{ r.p.m.}$$

and angular speed $$\omega = 2\pi \times \frac{50}{60} = 5.24 \text{ rad/s}$$

∴ Power of the motor $= T.\omega = 211.45 \times 5.24 = 1108 \text{ W} = 1.108 \text{ kW}$

23. Though there are many types of belts used these days, yet the following are important from the subject point of view :

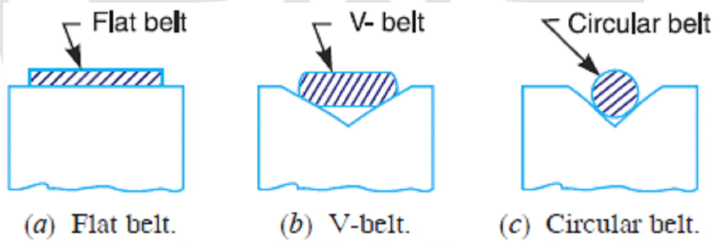


Figure : Types of Belts

- ***Flat Belt :***

  The flat belt, as shown in figure (a), is mostly used in the factories and workshops, where a moderate amount of power is to be transmitted, from one pulley to another when the two pulleys are not more than 8 metres apart.

- ***V-Belt :***

  The V-belt, as shown in figure (b), is mostly used in the factories and workshops, where a moderate amount of power is to be transmitted, from one pulley to another, when the two pulleys are very near to each other.

- ***Circular belt or Rope :***

  The circular belt or rope, as shown in figure (c), is mostly used in the factories and workshops, where a great amount of power is to be transmitted, from one pulley to another, when the two pulleys are more than 8 meters apart.

If a huge amount of power is to be transmitted, then a single belt may not be sufficient. In such a case, wide pulleys (for V-belts or circular belts) with a number of grooves are used. Then a belt in each groove is provided to transmit the required amount of power from one pulley to another.

24. The term 'generating' in gear cutting stands for development of involute curve by straight cutting edges of the cutter, which . produces a series of facets on the blank so as to form the involute profile. The cutter aud the blank behave as two mating gears in working contact. This generating action is easier to follow with reference to a rack and a pinion. Let the rack be made out of a hard metal and pinion blank from a softer material, say plastics (shown in figure). On moving the rack over the plastic blnnk and permitting the blank to rotate about its own axis Ihc rack will mould the profile of its teeth on the blank.

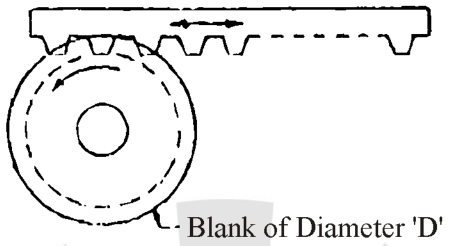


Figure : Rack moving on a Plastic Pinion

The linear speed of both being kept same. In actual practice since the blank is of metal therefore, moulding is not possible and as such the rack teeth should perform cutting action. This cutting action is obtained by reciprocating ihc rack cutter about an axis which is perpendicular to the paper or parallel lo the axis of ihc blnnk. After each cutting stroke ihc blnnk is rolled through one pilch while ihc cutter conducts return stroke. The reciprocating speed of the cutter is quite high. The generating action of the rack is dingrnirmtically represented in (shown in figure) which shows the successive position of the gear relative to rack developing involute profile.

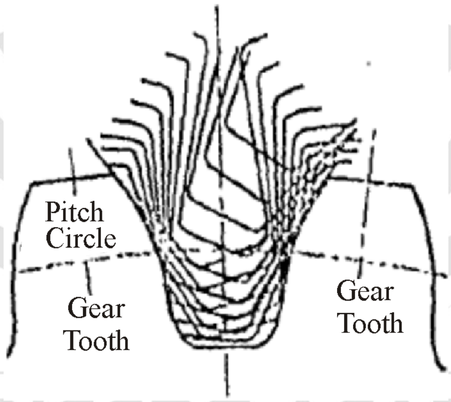


Figure : Generating Action of a rack

In gear cutting practice the rack is seldom used for generating the teeth. The cutter is cither a pinion or a worm with relieved cutting cdges.

25.
- Eliminales the laborious marking out of each work piece before machining and consequently eliminates cosily selling up according to the marking lines on machine tool beds.
- Increases machining accuracy and ensures 'ntcrchangeability because the work piece is automatically located without aligning on the machine tool and because the cutting tool is guided.
- Increases, prodnclivity due lo increasing the speeds, feeds and depth of cut. This becomes possible in a jig or fixture due to high clamping rigidity.
- Increases productivity due to increasing Ihc workpiccts simultaneously machined or ihe number of cutting tools operating.

Essential difference between a jig and a fixture is that the former incorporates bushes that guide the tools employed, whilst the latter holds the component, that is the article being machined, with the cutters working independently of it.

26. We have discussed in the previous articles that the cast iron contains small percentages of silicon, sulphur, manganese and phosphorous. The effect of these impurities on the cast iron are as follows :

- ***Silicon :***

  It may be present in cast iron upto 4%. It provides the formation of free graphite which makes the iron soft and easily machinable. It also produces sound castings free from blow-holes, because of its high affinity for oxygen.

- ***Sulphur :***

  It makes the cast iron hard and brittle. Since too much sulphur gives unsound casting, therefore, it should be kept well below 0.1% for most foundry purposes.

- ***Manganese :***

  It makes the cast iron white and hard. It is often kept below 0.75%. It helps to exert a controlling influence over the harmful effect of sulphur.

- ***Phosphorus :***

  It aids fusibility and fluidity in cast iron, but induces brittleness. It is rarely allowed to exceed 1%. Phosphoric irons are useful for casting of intricate design and for many light engineering castings when cheapness is essential.

27. The steel hardened by rapid quenching is very hard and brittle. It also contains internal stresses which are severe and unequally distributed to cause cracks or even rupture of hardened steel. The tempering (also known as drawing) is, therefore, done for the following reasons :

- To reduce brittleness of the hardened steel and thus to increase ductility.
- To remove the internal stresses caused by rapid cooling of steel.
- To make steel tough to resist shock and fatigue.

The tempering process consists of reheating the hardened steel to some temperature below the lower critical temperature, followed by any desired rate of cooling. The exact tempering temperature depends upon the purpose for which the article or tool is to be used.

28. Given: $D = 1.2 \text{ m} = 1200 \text{ mm}$

$\sigma = 100 \text{ MPa} = 100 \text{ N/mm}^2$

$E = 200 \text{ kN/mm}^2 = 200 \times 10^3 \text{ N/mm}^2$

$\alpha = 6.5 \times 10^{-6} \text{ per } ^\circ\text{C}$

Internal diameter of the tyre :

Let, d = Internal diameter of the tyre.

We know that hoop stress (σ), $$100 = \frac{E(D-d)}{d} = \frac{200\times10^3(D-d)}{d}$$

$$\therefore \quad \frac{D-d}{d} = \frac{100}{200\times10^3} = \frac{1}{2\times10^3} \qquad ...(1)$$

$$\frac{D}{d} = 1+\frac{1}{2\times10^3} = 1.0005$$

$$\therefore \quad d = \frac{D}{1.0005} = \frac{1200}{1.0005} = 1199.4 \text{ mm} = 1.1994 \text{ m}$$

Least temperature to which the tyre must be heated :

Let, t = Least temperature to which the tyre must be heated.

We know that $\pi D = \pi d + \pi d.\alpha.t = \pi d(1 + \alpha.t)$

$$\alpha.t = \frac{\pi D}{\pi d} - 1 = \frac{D-d}{d} = \frac{1}{2\times10^3}$$

From equation (1), we get

$$\therefore \quad t = \frac{1}{\alpha\times2\times10^3} = \frac{1}{6.5\times10^{-6}\times2\times10^3} = 77^oC$$

29. Given, $l = 2.4 \text{ m} = 2400 \text{ mm}$

$A = 30 \times 30 = 900 \text{ mm}^2$

$P = 500 \text{ kN} = 500 \times 10^3 \text{ N}$

$\frac{1}{m} = 0.25$

$E = 0.2 \times 10^6 \text{ N/mm}^2$

Let δV = Increase in volume.

We know that volume of the rod, V = Area × Length = 900 × 2400 = 2160 × 10^3 mm^3

and Young's modulus, $E = \frac{\text{Stress}}{\text{Strain}} = \frac{(P/A)}{\varepsilon}$

$$\therefore \quad \varepsilon = \frac{P}{A.E} = \frac{500\times10^3}{900\times0.2\times10^6} = 2.8\times10^{-3}$$

We know that volumetric strain

$$\frac{\delta V}{V} = \varepsilon\left(1-\frac{2}{m}\right) = 2.8\times10^{-3}(1-2\times0.25) = 1.4\times10^3$$

$$\therefore \quad \delta V = V\times1.4\times10^{-3}$$

$$= 2160\times10^3\times1.4\times10^{-3} = 3024 \text{ mm}^3$$

30. According to this theory, the failure or yielding occurs at a point in a member when the maximum shear stress in a bi-axial stress system reaches a value equal to the shear stress at yield point in a simple tension test. Mathematically,

$$\tau_{max} = \frac{\tau_{yt}}{F.S.} \quad ...(1)$$

Where, τ_{yt} = Maximum shear stress in a bi-axial stress system

τ_{yt} = Shear stress at yield point as determined from simple tension test

and F.S. = Factor of safety.

Since the shear stress at yield point in a simple tension test is equal to one-half the yield stress in tension, therefore the equation (1) may be written as

$$\tau_{max} = \frac{\sigma_{yt}}{2\times F.S.}$$

This theory is mostly used for designing members of ductile materials.

31. Given :

$$b = 150 \text{ mm}$$
$$d = 120 \text{ mm}$$
$$P = 180 \text{ kN} = 180 \times 10^3 \text{ N}$$
$$e = 10 \text{ mm}$$

We know that cross-sectional area of the strut,

$$A = b.d = 150 \times 120 = 18 \times 10^3 \text{ mm}^2$$

$\therefore$ Direct compressive stress, $\sigma_0 = \frac{P}{A} = \frac{180\times10^3}{18\times10^3} = 10 \text{ N/mm}^2 = 10 \text{ MPa}$

Section modulus for the strut, $Z = \frac{I_{YY}}{y} = \frac{d.b^3/12}{b/2} = \frac{d.b^2}{6} = \frac{120(150)^2}{6} = 450 \times 10^3 \text{ mm}^3$

Bending moment, $M = P.e = 180 \times 10^3 \times 10 = 1.8 \times 10^6$ N-mm

$\therefore$ Bending stress, $\sigma_b = \frac{M}{Z} = \frac{1.8\times10^6}{450\times10^3} = 4 \text{ N/mm}^2 = 4 \text{ MPa}$

Since σ_0 is greater than σ_b, therefore the entire cross-section of the strut will be subjected to compressive stress. The maximum intensity of compressive stress will be at the edge AB and minimum at the edge CD.

$\therefore$ Maximum intensity of compressive stress at the edge AB

$$= \sigma_0 + \sigma_b = 10 + 4 = 14 \text{ MPa}$$

and minimum intensity of compressive stress at the edge CD

$$= \sigma_0 - \sigma_b = 10 - 4 = 6 \text{ MPa}$$

32. Let, σ_u = Minimum ultimate strength in MN/m²

We know that the mean or average stress,

$$\sigma_m = \frac{\sigma_1+\sigma_2}{2} = \frac{300+(-150)}{2} = 75 \text{ MN/m}^2$$

and variable stress, $\sigma_v = \frac{\sigma_1-\sigma_2}{2} = \frac{300-(-150)}{2} = 225 \text{ MN/m}^2$

According to modified Goodman relation

We know that according to modified Goodman relation,

$$\frac{1}{F.S.} = \frac{\sigma_m}{\sigma_u} + \frac{\sigma_v}{\sigma_e}$$

$$\frac{1}{2} = \frac{75}{\sigma_u} + \frac{225}{0.5\sigma_u} = \frac{525}{\sigma_u}$$

$\therefore$ $\sigma_u = 2 \times 525 = 1050 \text{ MN/m}^2$

[PART : C]

33. Given :

$$m = 1 \text{ kg}$$
$$m_1 = 2.5 \text{ kg}$$
$$s = 1.8 \text{ kN/m} = 1.8 \times 10^3 \text{ N/m}$$

We know that total length of rod, $l = 300 + 300 = 600 \text{ mm} = 0.6 \text{ m}$

$\therefore$ Mass moment of inertia of the system about A,

I_A = Mass moment of inertia of 1 kg about A + Mass moment of interia of 2.5 kg about A

$$= \frac{m.l^2}{3} + m_1.l^2 = \frac{1(0.6)^2}{3} + 2.5(0.6)^2 = 1.02 \text{ kg-m}^2$$

If the rod is given a small angular displacement θ and then released, the extension of the spring,

$$\delta = 0.3\sin\theta = 0.3\theta \text{ m}$$

($\because$ δ is very small, therefore substituting sin θ = θ)

$\therefore$ Restoring force = $s.\delta = 1.8 \times 10^3 \times 0.3\theta = 540\theta$ N

and restoring torque about A = $540\,\theta \times 0.3 = 162\,\theta$ N-m ...(1)

We know that disturbing torque about

$$A = I_A \times \alpha = 1.02\alpha \text{ N-m} \quad ...(2)$$

Equating equations (1) and (2)

$$1.02\,\alpha = 162\,\theta \text{ or } \frac{\alpha}{\theta} = \frac{162}{1.02} = 159$$

We know that frequency of oscillation, $n = \frac{1}{2\pi}\sqrt{\frac{\alpha}{\theta}} = \frac{1}{2\pi}\sqrt{159} = 2.01$ Hz

34. The Davis steering gear is shown in figure. It is an exact steering gear mechanism. The slotted links AM and BH are attached to the front wheel axle, which turn on pivots A and B respectively.

The rod CD is constrained to move in the direction of its length, by the sliding members at P and Q. These constraints are connected to the slotted link AM and BH by a sliding and a turning pair at each end. The steering is affected by moving CD to the right or left of its normal position. C′ D′ shows the position of CD for turning to the left.

Let a = Vertical distance between AB and CD

b = Wheel base

d = Horizontal distance between AC and BD

c = Distance between the pivots A and B of the front axle

x = Distance moved by AC to AC′ = CC′ = DD′

and α = Angle of inclination of the links AC and BD, to the vertical

From triangle A A′ C′,

$$\tan(\alpha + \phi) = \frac{A'C'}{AA'} = \frac{d+x}{a} \quad ...(1)$$

From triangle A, A'C, $$\tan\alpha = \frac{A'C}{AA'} = \frac{d}{a} \quad ...(2)$$

From triangle B B'D', $$\tan(\alpha - \theta) = \frac{B'D'}{BB'} = \frac{d-x}{a} \quad ...(3)$$

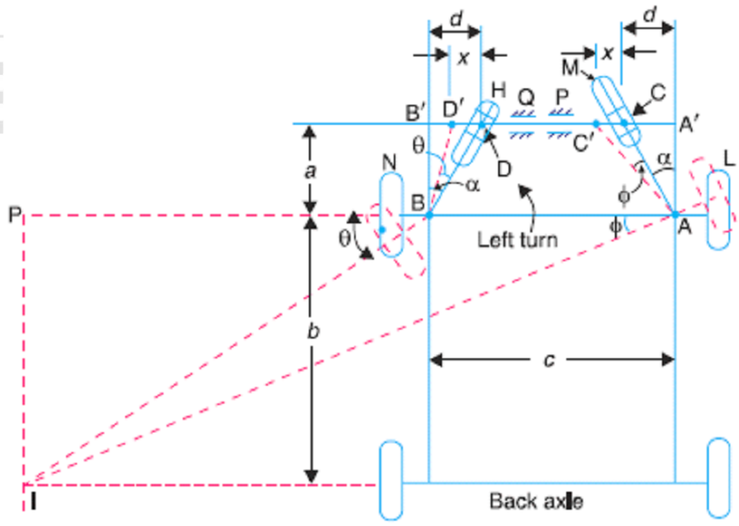


Figure : Davis steering Gear

We know that $\tan(\alpha + \phi) = \frac{\tan\alpha + \tan\phi}{1 - \tan\alpha.\tan\phi}$

or $\frac{d+x}{a} = \frac{(d/a) + \tan\phi}{1 - (d/a)\times\tan\phi} = \frac{d + a\tan\phi}{a - d\tan\phi}$

$$(d + x)(a - d\tan\phi) = a(d + a\tan\phi)$$

$$a.d - d^2\tan\phi + a.x - d.x\tan\phi = a.d + a^2\tan\phi$$

$$\tan\phi\,(a^2 + d^2 + d.x) = ax \text{ or } \tan\phi = \frac{a.x}{a^2 + d^2 + d.x} \quad ...(4)$$

Similarly, from $\tan(\alpha + \theta) = \frac{d-x}{a}$, we get

$$\tan\theta = \frac{ax}{a^2 + d^2 - d.x} \quad ...(5)$$

We know that for correct steering,

$$\cos\phi - \cot\theta = \frac{c}{b} \text{ or } \frac{1}{\tan\phi} - \frac{1}{\tan\theta} = \frac{c}{b}$$

$$\frac{a^2 + d^2 + d.x}{a.x} - \frac{a^2 + d^2 - d.x}{a.x} = \frac{c}{b}$$

From equations (4) and (5)

or $\frac{2d.x}{a.x} = \frac{c}{b}$ or $\frac{2d}{a} = \frac{c}{b}$

∴ $2\tan\alpha = \frac{c}{b}$ or $\tan\alpha = \frac{c}{2b}$ $\left(\because \frac{d}{a} = \tan\alpha\right)$

Note : *Though the gear is theoretically correct, but due to the presence of more sliding members, the war will be increased which produces slackness between the sliding surfaces, thuse eliminating the original accuracy. Hence Davis steering gear is not in common use.*

35. $rt = \frac{0.21}{0.3} = 0.70$

$$\tan\phi = \frac{0.73(-10)}{1 - 0.70\sin(-10)} = \frac{0.70\times0.984}{1 + 0.70\times0.173} = \frac{0.686}{1.121} = 0.615$$

$$\phi = 3.15^o$$

Shear strain $= \tan(\phi - \alpha) + \cot\phi = \tan(31.5 + 10) + \cot 31.5$

$= 0.884 + 1.631 = 2.515$

Strain Energy per unit volume = Shear stress × Shear strain

$$\text{Shear Stress} = \frac{F_s}{A_s} = \frac{F_c\cos\phi - F_t\sin\phi}{A_0}\times\sin\phi$$

$$= \left(\frac{125\times852 - 30\times0.522}{0.021\times2.1}\right)\times0.522 = \frac{106.5 - 15.660}{0.441}\times0.522$$

$= 90.740 \times 1.185 = 107.2$ kg/mm^2

∴ Shear Energy $= 107.2 \times 2.515 = 270$ kg/mm^2

36. Thread grinding method is adopted for preparing threads on the work under two circumstances ; firstly, when a very high degree of precision is required on the threads and secondly, when the hard-ness of the material is quite high (Rockwell C27 and above) or the material is very soft.

Like milling, thread grinding is also carried on in two ways. The first is adopted for blanks of larger lengths when a thin disc type grinding wheel is used. The wheel is pre-fonned according to the thread profile. The wheel while running keeps traversing the length of the thread (shown in the figure). The wheel runs at a speed ranging from 2000 m.p,m. to 3000 m.p.m. and traverses at a speed of 2 to 5 m.p.m. The threads are finished in one pass of the grinding wheel.

The other method is adopted for threads extending over smaller lengths and finishing at the shoulder. The wheel has more than one per-formed cutting edges, and the width of the wheel is slightly more than the length over which the threads are to be foremd, shown in the figure.

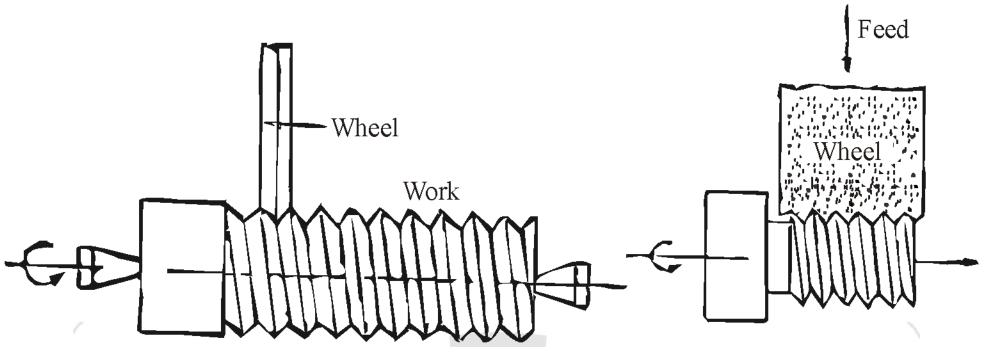


Figure : Two Methods of thread Grinding

To start the cutting action, the wheel is rotated at high cutting speed and then fed to entire depth of the thread. The next step is the movement of the thread throught 1.25 revolution and axial advancement of the work by a distance equal to one pitch.

THREAD ROLLING :

Thread rolling is essentialy a cold working process in which the required thread form is impressed on the cylindrical workplace by rolling it in between hard metal dies. The dies are forced on rotating blank until threads are formed by plastic displacement of metal. The process is carried out on suitable machines by employing fiat, dies or circular threaded rolls.

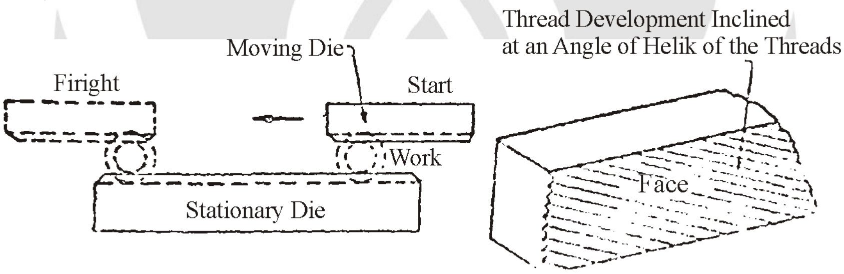
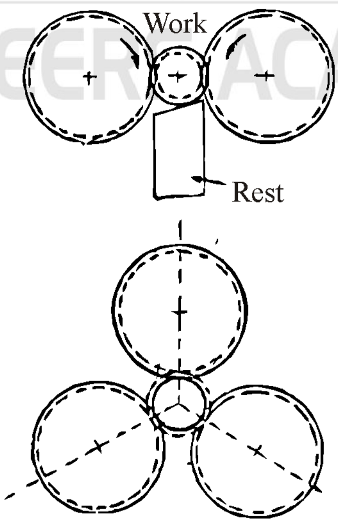


Figure : Thread Rolling with flat dies

The flat dies have the reciprocating motion and the threads arc finished in one stroke, shown in the figure. The circular rolls rotary motion and the work is fed in either of the three particular ways as indicated in the figure.



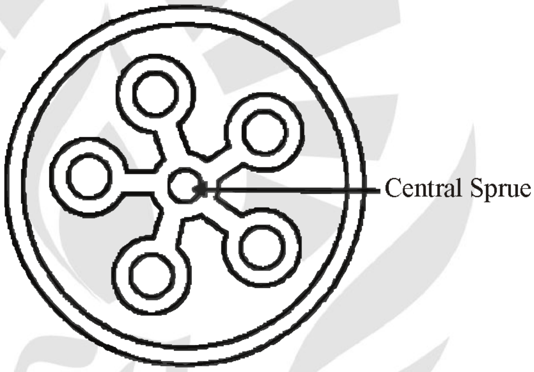
The thread rolling dies and rolls are made of high speed steel or high carbon high chromium oil and air hardening tool steels (1.5% Cr and vanadium and molybdenum).

Use of flat dies is limited to about 25 mm diameter blanks but this method provides a faster rate of production. The rate of production varies from 250 per minute to 40 per minute depending upon the fact whether the blank diameter is smaller or larger.

37. In this process the molten metal is continuously poured in to a mold cavity around which a facility for quick cooling the molten metal to the point of solidification. The solidified metal is then continuously extracted from the mold at predetermined rate. This process is classified into two categories namely Asarco and Reciprocating. In reciprocating process, molten metal is poured into a holding furnace. At the bottom of this furnace, there is a valve by which the quantity of flow can be changed. The molten metal is poured into the mold at a uniform speed. The water cooled mold is reciprocated up and down. The solidified portion of the casting is withdrawn by the rolls at a constant speed. The movement of the rolls and the reciprocating motion of the rolls are fully mechanized and properly controlled by means of cams and follower arrangements.

Advantages of Continuous Casting :

- The process is cheaper than rolling figure. Article produced by semicentrifugal casting process.



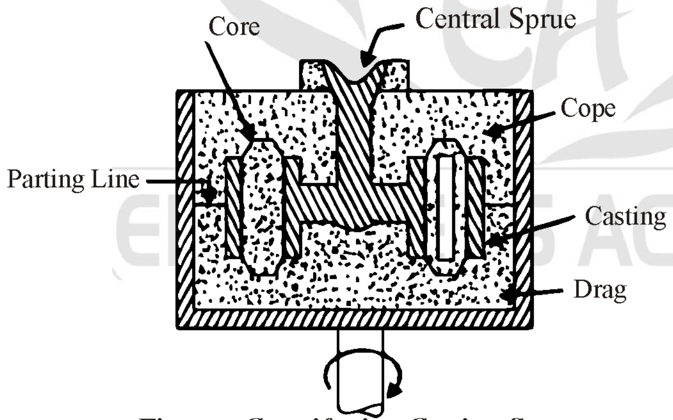


Figure : Centrifuging Casting Setup

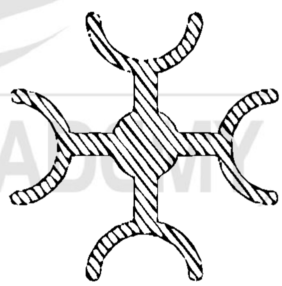


Figure : Article Produced by Centrifuging Casting Process

- 100% casting yield.
- The process can be easily mechanized and thus unit labor cost is less.
- Casting surfaces are better.
- Grain size and structure of the casting can be easily controlled.

Applications of Continuous Casting :

- It is used for casting materials such as brass, bronzes, zinc, copper, aluminium and its alloys, magnesium, carbon and alloys etc.
- Production of blooms, billets, slabs, sheets, copper bar etc.
- It can produce any shape of uniform cross-section such as round, rectangular, square, hexagonal, fluted or gear toothed etc.

38. Shielded metal arc welding (SMAW) is a commonly used arc welding process manually carried by welder. It is an arc welding process in which heat for welding is produced through an electric arc set up between a flux coated electrode and the workpiece. The flux coating of electrode decomposes due to arc heat and serves many functions, like weld metal protection, arc stability etc. Inner core of the electrode supply the filler material for making a weld. The basic setup of MMAW is depicted in figure (a), (b) and the configuration of weld zone is shown in figure. If the parent metal is thick it may be necessary to make two or three passes for completing the weld. A typical multi pass bead in this case is shown in figure.

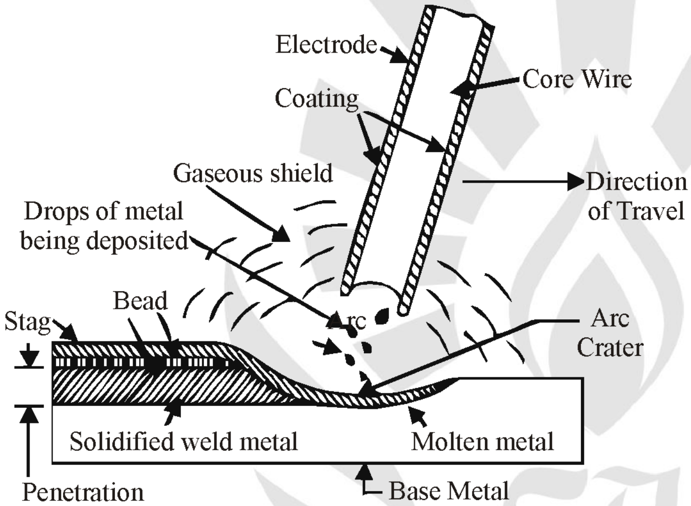


Figure : Arc Welding operation

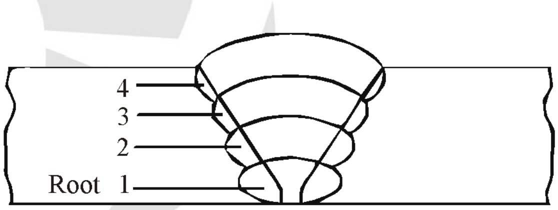


Figure : A typical multi pass Bead

Advantages :

- Shielded Metal Arc Welding (SMAW) can be carried out in any position with highest weld quality.
- MMAW is the simplest of all the arc welding processes.
- This welding process finds innumerable applications, because of the availability of a wide variety of electrodes.
- Big range of metals and their alloys can be welded easily.
- The process can be very well employed for hard facing and metal resistance etc.
- Joints (e.g., between nozzles and shell in a pressure vessel) which because of their position are difficult to be welded by automatic welding machines can be easily accomplished by flux shielded metal arc welding.
- The MMAW welding equipment is portable and the cost is fairly low.

Limitations :

- Due to flux coated electrodes, the chances of slag entrapment and other related defects are more as compared to MIG and TIG welding.
- Duo to fumes and particles of slag, the arc and metal transfer is not very clear and thus welding control in this process is a bit difficult as compared to MIG welding.
- Due to limited length of each electrode and brittle flux coating on it, mechanization is difficult.

- In welding long joints (e.g., in pressure vessels), as one electrode finishes, the weld is to be progressed with the next electrode. Unless properly cared, a defect (like slag inclusion or insufficient penetration) may occur at the place where welding is restarted with the new electrode.
- The process uses stick electrodes and thus it is slower as compared to MIG welding.

Applications :

- Today, almost all the commonly employed metals and their alloys can be welded by this process.
- Shielded metal arc welding is used both as a fabrication process and for maintenance and repair jobs.
- ***The process finds applications in :***
  (i) Building and Bridge construction
  (ii) Automotive and aircraft industry, etc.
  (iii) Air receiver, tank, boiler and pressure vessel fabrication
  (iv) Ship building
  (v) Pipes and
  (vi) Penstock joining

39. Mechanical working processes which are done above recrystallisation temperature of the metal are know as hot working processes. Some metals, such as lead and tin, have a low recrystallisation temperature and can be hot-worked even at room temperature, but most commercial metals require some heating. However, this temperature should not be too high to reach the solidus temperature; otherwise the metal will burn and become unsuitable for use. In hot working, the temperature of completion of metal working is important since any extra heat left after working aid in grain growth. This increase in size of the grains occurs by a process of coalescence of adjoining grains and is a function of time and temperature.

Grain growth results in poor mechanical properties. If the hot working is completed just above the recrystallisation temperature then the resultant grain size would be fine. Thus for any hot working process the metal should be heated to such a temperature below its solidus temperature, that after completion of the hot working its temperature will remain a little higher than and as close as possible to its reerystalisation temperature

EFFECT OF HOT WORKING ON MECHANICAL PROPERTIES OF METALS :

- This process is generally performed on a metal held at such a temperature that the metal does not work-harden. A few metals e.g., Pb and Sn (since they possess low crystallization temperature) can be hot worked at room temperature.
- Raising the metal temperature lowers the stresses required to produce deformations and increases the possible amount of deformation before excessive work hardening takes place.
- Hot working is preferred where large deformations have to be performed that do not have the primary purpose of causing work hardening.
- Hot working produces the same net results on a metal as cold working and annealing. It does not strain harden the metal.
- In hot working processes, compositional irregularities are ironed out and nonmetallic impurities are broken up into small, relatively harmless fragments, which are uniformly dispersed throughout the metal instead of being concentrated in large stress-raising metal working masses.
- Hot working such as rolling process refines grain structure. The coarse columnar dendrites of cast metal are refined to smaller equiaxed grains with corresponding improvement in mechanical properties of the component.
- Surface finish of hot worked metal is not nearly as good as with cold working, because of oxidation and scaling.
- One has to be very careful as regards the temperatures at which to start hot work and at which to stop because this affects the properties to be introduced in the hot worked metal.

- Too high a temperature may cause phase change and overheat the steel whereas too low temperature may result in excessive work hardening.
- Defects in the metal such as blowholes, internal porosity and cracks get removed or welded up during hot working.
- During hot working, self-annealing occurs and recrystallization takes place immediately following plastic deformation. This self-annealing action prevents hardening and loss of ductility.

MERITS OF HOT WORKING :

- As the material is above the recrystallisation temperature, any amount of working can be imparted since there is no strain hardening taking place.
- At a high temperature, the material would have higher amount of ductility and therefore there is no limit on the amount of hot working that can be done on a material. Even brittle materials can be hot worked.
- In hot working process, the grain structure of the metal is refined and thus mechanical properties improved.

Hot Working of Metals

- Porosity of the metal is considerably minimized.
- If process is properly carried out, hot work does not affect tensile strength, hardness, corrosion resistance, etc.
- Since the shear stress gets reduced at higher temperatures, this process requires much less force to achieve the necessary deformation.
- It is possible to continuously reform the grains in metal working and if the temperature and rate of working are properly controlled, a very favorable grain size could be achieved giving rise to better mechanical properties.
- Larger deformation can be accomplished more rapidly as the metal is in plastic state.
- No residual stresses are introduced in the metal due to hot working.
- Concentrated impurities, if any in the metal are disintegrated and distributed throughout the metal.
- Mechanical properties, especially elongation, reduction of area and izod values are improved, but fibre and directional properties are produced.
- Hot work promotes uniformity of material by facilitating diffusion of alloy constituents and breaks up brittle films of hard constituents or impurity namely cementite in steel.

DEMERITS OF HOT WORKING :

- Due to high temperature in hot working, rapid oxidation or scale formation and surface de-carburization take place on the metal surface leading to poor surface finish and loss of metal.
- On account of the loss of carbon from the surface of the steel piece being worked the surface layer loses its strength. This is a major disadvantage when the part is put to service.
- The weakening of the surface layer may give rise to a fatigue crack which may ultimately result in fatigue failure of the component.
- Some metals cannot be hot worked because of their brittleness at high temperatures.
- Because of the thermal expansion of metals, the dimensional accuracy in hot working is difficult to achieve.
- The process involves excessive expenditure on account of high cost of tooling. This however is compensated by the high production rate and better quality of components.
- Handling and maintaining of hot working setups is difficult and troublesome.

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