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$$P_t = 1092.59 N$$

$$\therefore M_t = P_t \frac{d_p'}{2}$$

$$M_t = 78666.48\ N \cdot mm$$
$$= 78.66\ N \cdot m$$

$$M_t = \frac{P \times 60}{2 \pi N}$$

$$P = 8240\ W$$
$$= 8.24\ kW \quad \text{Ans}$$

Ans 6.

Pr. angle $= 20°$
Power $= 5\ kW$
$\sigma_u = 410\ MPa$
$v = 5\ m/sec$

$N_p = 720\ rpm$
$N_g = 144\ rpm$
$C_s = 1.25$
$f_s = 2.0$

Assuming no. of teeth on pinion
$Z_p = 18$

Since $v = 5\ m/s$ (initial approx.)

$$C_v = \frac{3}{3+v} = \frac{3}{8} = 0.375$$

$$S_b = f_s P_{eff} = f_s \cdot \frac{C_s P_t}{C_v}$$

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$$M_t = \frac{P \times 60}{2\pi N} = \frac{5 \times 10^3 \times 60 \times 10^3}{2 \times \pi \times 720} = 66348 \text{ N·mm}$$

$$P_t = \frac{M_t}{d_p/2} = \frac{66348}{3(18/2)} = \frac{7372}{m} \text{ N}$$

$$\sigma_b \, y \, m = \frac{f_s C_s P_t}{C_\theta}$$

assuming $b = 10m$ & $y = 0.308$
(for $Z_P = 18$)

further material is same surface pinion is designed

$$\sigma_b = \frac{\sigma_u}{3} = \frac{410}{3} = 136.6 \text{ MPa}$$

Putting all the values

$$136.6 \times 10m \times 0.308 \times m$$

$$= (2.0) \times \left(\frac{1.25}{0.375}\right) \times \left(\frac{7372}{m}\right)$$

$m = 4.88$ mm ~ 5 mm Ans

so, $d_{p'} = m Z_P = 90$ mm

$d_g = m Z_g = 5 \times 90 = 450$ mm

$$P_t = \frac{7372}{m} = 1474.4 \text{ N}$$

Now we need to find dynamic load
We know for grade 6

$e = 8 + 0.63 \phi$

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for pinion. $\phi = m + 0.25\sqrt{Dc}$

$= 5 + 0.25\sqrt{90}$

$= 8 + 0.63\phi = 12.644\ \mu m$

and $e_g = 14.491$

$e = e_p + e_g = 27.135\ \mu m$

$= 27.135 \times 10^{-3}\ mm$

Now we need to find dynamic load

$$P_d = \frac{21v(ceb + P_t)}{21v + \sqrt{ceb + P_t}}$$

We know for grade 6

$e = 8 + 0.63\phi$

for pinion $\phi = m + 0.25\sqrt{dp'}$

$5 + 0.25\sqrt{90}$

$e_p = 8 + 0.63\phi = 12.644$

$e_g = 4.421\ \mu m$

$e = e_p + e_g = 27.13\ \mu m$

$= 27.135 \times 10^{-3}\ mm$

The deformation factor $c = 11400\ MPa$

$$v = \frac{\pi d_p' N_P}{60000} = \frac{\pi \times 90 \times 720}{60000}$$

$v = 3.39\ m/s$

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Now $P_d = \dfrac{210\,(C e b + P_t)}{210 + \sqrt{(C e b + P_t)}}$

putting all values

$P_d = 5993\,N$ Ans

so effective load, $P_{eff} = C_s P_t + P_d$
$= (1.25 \times 1474.4) + 5993$
$= 7836\,N$

Beam strength

$S_b = m \cdot b \cdot \sigma_b \cdot y$
$= 5 \times 50 \times \left(\frac{410}{3}\right) \times 0.308$

$= 10523.33\,N$

Corrected factor of safety

$S_b = f_s P_{eff}$

or $f_s = \dfrac{S_b}{P_{eff}} = \dfrac{10523.33}{7836} = 1.34$

Surface hardness

Given $f_s = 2.0$ for wear strength
so $S_w = f_s P_{eff}$
so $S_w = 2 \times 7836 = 15672\,N$

$\therefore S_w = d_p' \, b \cdot Q \cdot K$

Or $15672 = 90 \times 50 \times 1.66 \times K$

$K = 2.097$

We know for 20° Pr. angle steel gears

$$K = 0.16 \times \left(\frac{BHN}{100}\right)^2$$

$$\therefore BHN = \sqrt{\frac{K \times 100 \times 100}{0.16}}$$

$= 360$ Ans