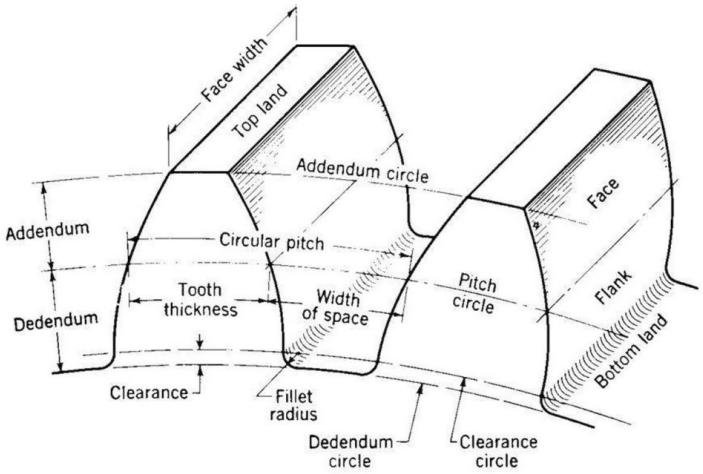
Gear Calculations

The geometric parameters of the pinions and gears were determined following the ISO nomenclature for spur gears. The calculations performed are detailed below:



Pinion

- **Module** (m): $m = \frac{d_o}{z+2} = \frac{50\,\text{mm}}{22} = 2.27\,\text{mm}$
- **Pitch diameter** (d): $d = m \times z = 2.27\,\text{mm} \times 20 = 45.4\,\text{mm}$
- **Circular pitch** (p): $p = \pi \times m = \pi \times 2.27\,\text{mm} = 7.1314\,\text{mm}$
- **Addendum** (h_a): $h_a = m = 2.27\,\text{mm}$
- **Clearance** (c): $c = 0.25 \times m = 0.25 \times 2.27\,\text{mm} = 0.5675\,\text{mm}$
- **Dedendum** (h_f): $h_f = m + c = 2.27\,\text{mm} + 0.5675\,\text{mm} = 2.8375\,\text{mm}$
- **Total tooth height** (h): $h = h_a + h_f = 2.27\,\text{mm} + 2.8375\,\text{mm} = 5.1075\,\text{mm}$
- **Root diameter** (d_r): $d_r = d - 2 \times h_f = 45.4\,\text{mm} - 2 \times 2.8375\,\text{mm} = 39.725\,\text{mm}$
- **Tooth thickness** (s): $s = \frac{p}{2} = \frac{7.1314\,\text{mm}}{2} = 3.565\,\text{mm}$
- **Base diameter** (d_b): $d_b = d \times \cos(20°) = 45.4\,\text{mm} \times 0.9397 \approx 42.66\,\text{mm}$

Ring Gear

- **Module** (m): $m = \frac{d_o}{z+2} = \frac{140\,\text{mm}}{62} = 2.25\,\text{mm}$
- **Pitch diameter** (d): $d = m \times z = 2.25\,\text{mm} \times 60 = 135\,\text{mm}$
- **Circular pitch** (p): $p = \pi \times m = \pi \times 2.25\,\text{mm} = 7.0685\,\text{mm}$
- **Addendum** (h_a): $h_a = m = 2.25\,\text{mm}$
- **Clearance** (c): $c = 0.25 \times m = 0.25 \times 2.25\,\text{mm} = 0.5625\,\text{mm}$
- **Dedendum** (h_f): $h_f = m + c = 2.25\,\text{mm} + 0.5625\,\text{mm} = 2.8145\,\text{mm}$
- **Total tooth height** (h): $h = h_a + h_f = 2.25\,\text{mm} + 2.8145\,\text{mm} = 5.0646\,\text{mm}$
- **Root diameter** (d_r): $d_r = d - 2 \times h_f = 135\,\text{mm} - 2 \times 2.8145\,\text{mm} = 129.371\,\text{mm}$
- **Tooth thickness** (s): $s = \frac{p}{2} = \frac{7.0685\,\text{mm}}{2} = 3.53\,\text{mm}$
- **Base diameter** (d_b): $d_b = d \times \cos(20°) = 135\,\text{mm} \times 0.9397 \approx 126.86\,\text{mm}$

Table 1: Summary of Key Gear Parameters

Parameter	**Pinion**	**Ring Gear**
Teeth (z)	20	60
Module (m)	2.27 mm	2.25 mm
Pitch Diameter (d)	45.4 mm	135 mm
Outside Diameter (d_o)	50 mm	140 mm
Total Tooth Height (h)	5.1075 mm	5.0646 mm
Gear Ratio	1:3 (per stage)	