

## 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 ( $m$ ):**  $m = \frac{de}{z+2} = \frac{50 \text{ mm}}{22} = 2.27 \text{ mm}$
- **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 ( $ha$ ):**  $ha = m = 2.27 \text{ mm}$
- **Clearance coefficient ( $f$ ):**  $f = 0.25 \times m = 0.25 \times 2.27 \text{ mm} = 0.5675 \text{ mm}$
- **Dedendum ( $hf$ ):**  $hf = m + f = 2.27 \text{ mm} + 0.5675 \text{ mm} = 2.8375 \text{ mm}$
- **Total tooth height ( $h$ ):**  $h = ha + hf = 2.27 \text{ mm} + 2.8375 \text{ mm} = 5.1075 \text{ mm}$
- **Root diameter ( $df$ ):**  $df = d - 2 \times hf = 45.4 \text{ mm} - 2 \times 2.8375 \text{ mm} = 39.725 \text{ mm}$
- **Tooth thickness ( $s$ ):**  $s = \frac{p}{2} = \frac{7.1314 \text{ mm}}{2} = 3.565 \text{ mm}$
- **Base diameter ( $db$ ):**  $db = d \times \cos(20^\circ) = 45.4 \text{ mm} \times 0.9397 \approx 42.66 \text{ mm}$

### Ring Gear

- **Module ( $m$ ):**  $m = \frac{de}{z+2} = \frac{140 \text{ mm}}{62} = 2.25 \text{ mm}$
- **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 ( $ha$ ):**  $ha = m = 2.25 \text{ mm}$
- **Clearance coefficient ( $f$ ):**  $f = 0.25 \times m = 0.25 \times 2.25 \text{ mm} = 0.5625 \text{ mm}$
- **Dedendum ( $hf$ ):**  $hf = m + f = 2.25 \text{ mm} + 0.5625 \text{ mm} = 2.8145 \text{ mm}$
- **Total tooth height ( $h$ ):**  $h = ha + hf = 2.25 \text{ mm} + 2.8145 \text{ mm} = 5.0646 \text{ mm}$
- **Root diameter ( $df$ ):**  $df = d - 2 \times hf = 135 \text{ mm} - 2 \times 2.8145 \text{ mm} = 129.371 \text{ mm}$
- **Tooth thickness ( $s$ ):**  $s = \frac{p}{2} = \frac{7.0685 \text{ mm}}{2} = 3.53 \text{ mm}$
- **Base diameter ( $db$ ):**  $db = d \times \cos(20^\circ) = 135 \text{ mm} \times 0.9397 \approx 126.86 \text{ mm}$

Table 1: Key Gear Parameters

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