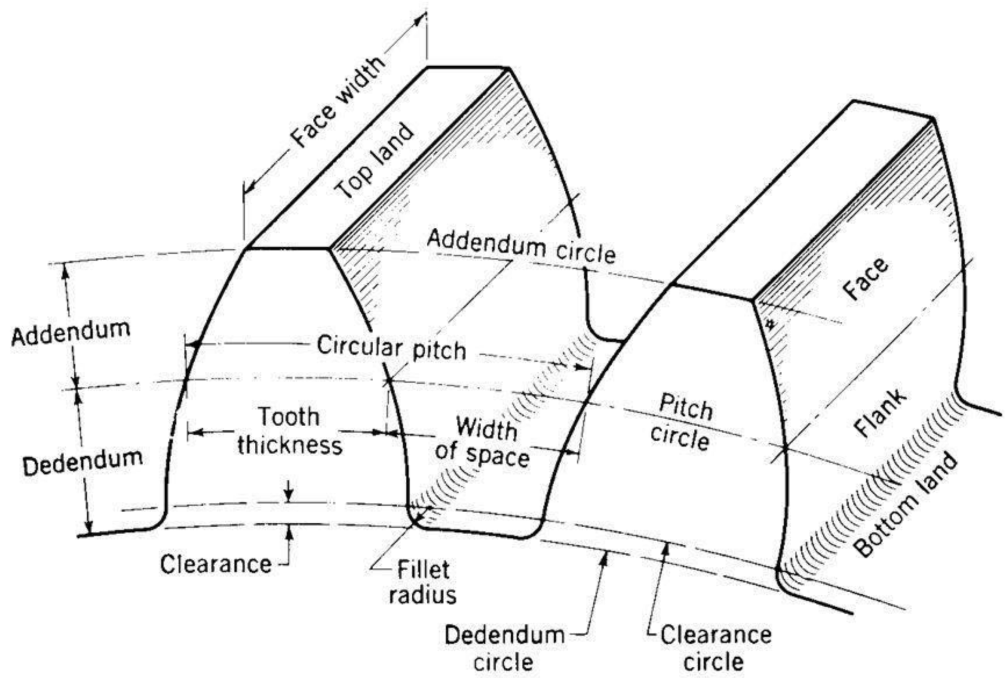
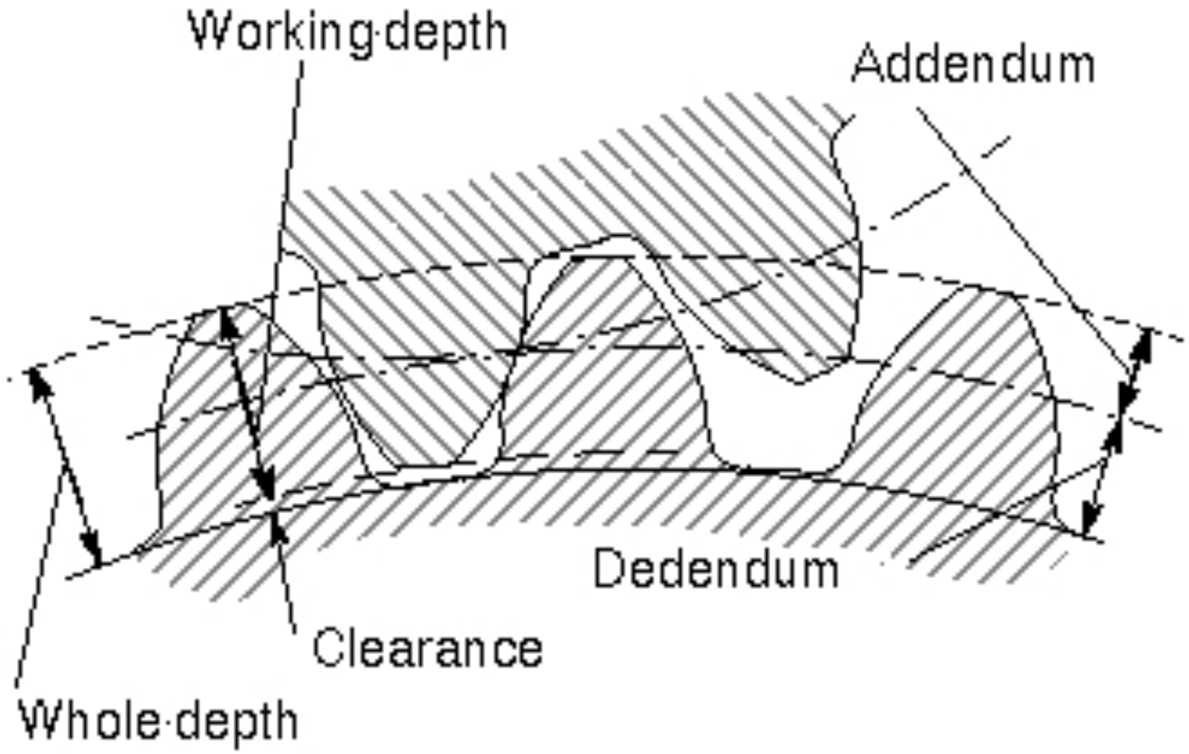
Problem 01

There is an external gear pump (assumed it is a module gear) with teeth number $Z = 13$, the diameter of the addendum circle $D_0 = 75\ mm$, the distance between centre points $A = 65\ mm$,
gear width $B = 35\ mm$, volumetric efficiency $\eta = 90\%$, rotating speed $N = 1500\ rpm$. Calculate the flowrate of the pump.

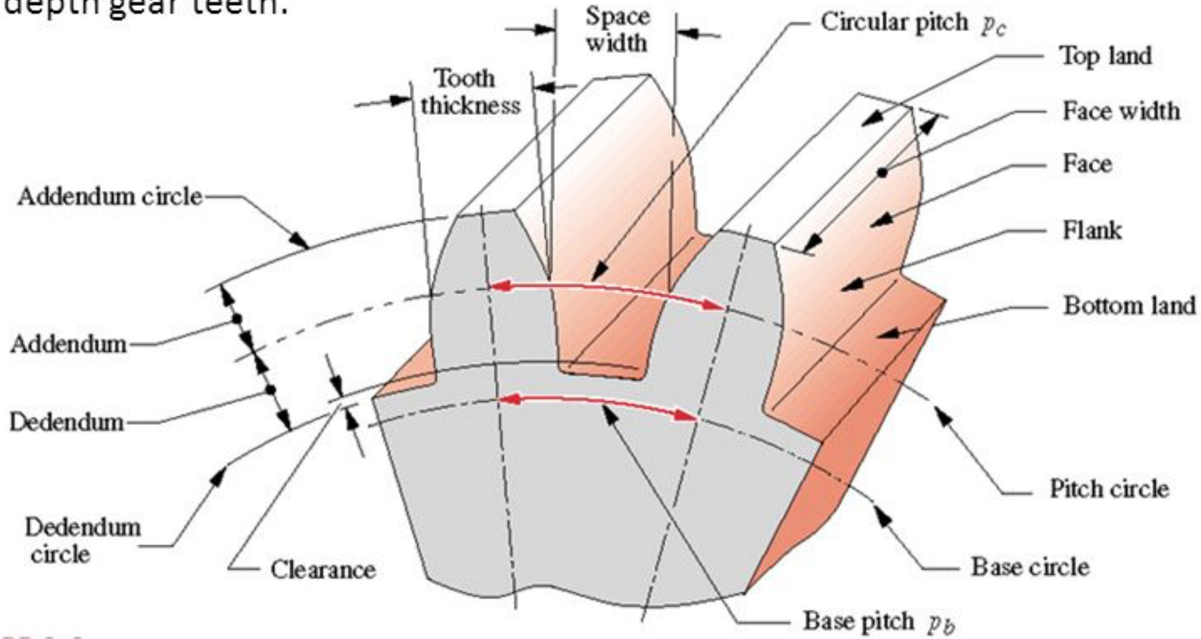
Gear Nomenclature

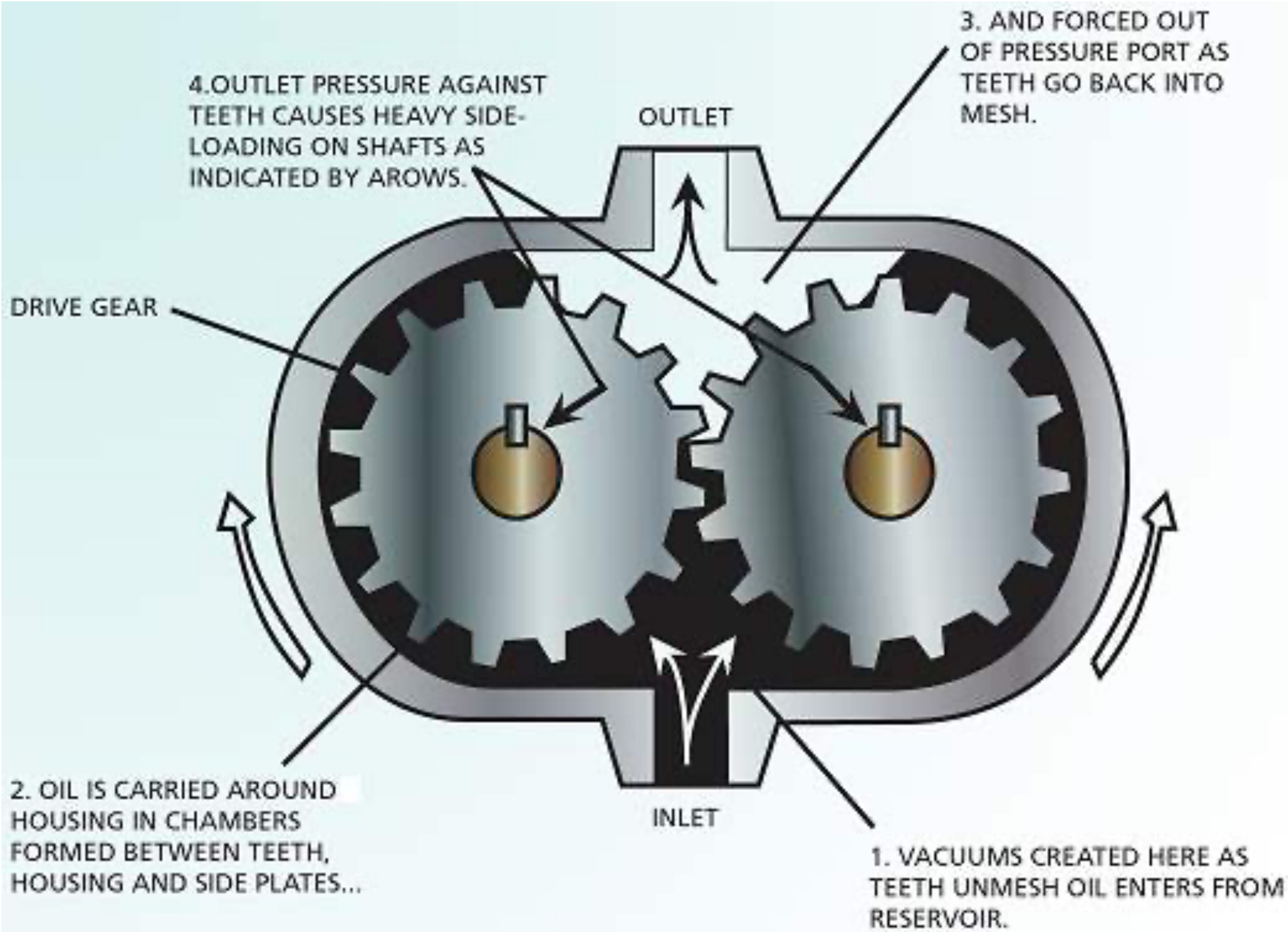



Working·depth
Addendum
Dedendum
Clearance
Whole·depth

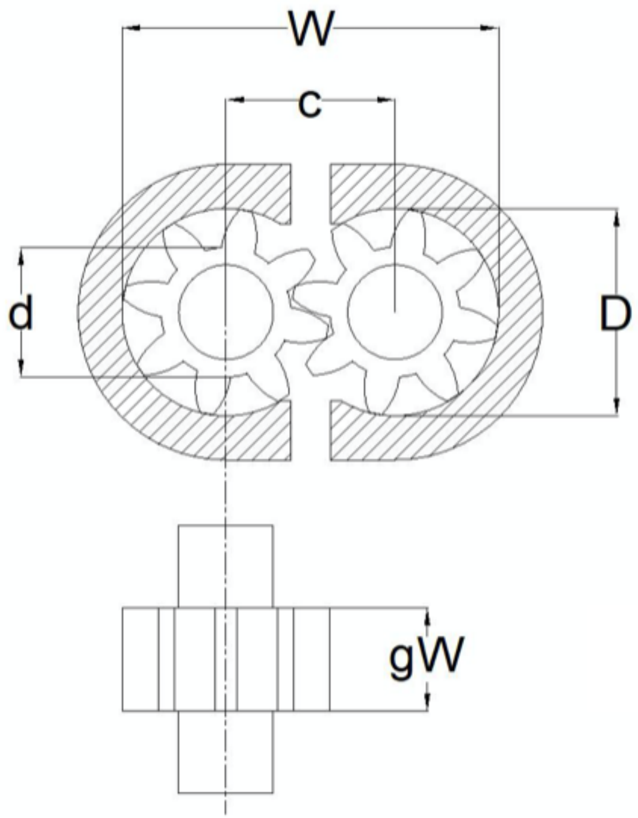
Addendum and Dedendum

- The gear tooth must project both below and above the rolling cylinder surface (pitch circle) and the involute only exists outside of the base circle. The amount of tooth that sticks out above the pitch circle is the addendum, *a*, and the amount that goes below is dedendum, *b*. These are related by $a_p = a_g$ and $b_p = b_g$ for pinion and gear, respectively, are equal for standard, full-depth gear teeth.




3. AND FORCED OUT OF PRESSURE PORT AS TEETH GO BACK INTO MESH.
4.OUTLET PRESSURE AGAINST TEETH CAUSES HEAVY SIDE-LOADING ON SHAFTS AS INDICATED BY AROWS.
OUTLET
DRIVE GEAR
2. OIL IS CARRIED AROUND HOUSING IN CHAMBERS FORMED BETWEEN TEETH, HOUSING AND SIDE PLATES...
INLET
1. VACUUMS CREATED HERE AS TEETH UNMESH OIL ENTERS FROM RESERVOIR.

Estimate the volume in gear pump:



Measurements, typically mentioned in external gear pump displacement formulae:

D - gear external diameter
d - gear root diameter
W - bore Width
c - center distance
gW - gear Width

There are 2 common equations to estimate the volume

$$Volume = \frac{\pi}{4}(D^2 - d^2) \times (\text{gear width})$$

Or

$$Volume = \frac{\pi}{2}(D^2 - c^2) \times (\text{gear width})$$

However, the first equation maybe the most common equation.

Addendum circle diameter:

$$D_0 = 75\ mm$$

Number of teeth:

$$Z = 13$$

In gear pump, both gears are the same size.
Center distance between two gears is equal to pitch circle.

$$A = 65\,mm$$

Module, m can be calculated as:

$$m = \frac{\text{Pitch circle diameter}}{\text{number of teeth}} = \frac{65}{13} = 5\ mm$$

In general, for module gear, addendum is equal to the module value.

$$m = module = addendum$$

$$dedendum = addendum + clearance = 1.157 \times m = 5.785 \ \ mm$$

$$total\ depth = addendum + dedendum = 5 + 5.785 = 10.785 \ \ mm$$

Diameter of dedendum circle:

$$D_c = D_0 - 2(total\ depth) = 75 - 2(10.785) = 53.43 \ \ mm$$

We use first equation:

$$Volume = \frac{\pi}{4}(D_0^2 - D_c^2) \times (\text{gear width})$$

$$\text{Volume flowrate} = \frac{\pi}{4}(75^2 - 53.43^2) \times (35) \times \left(\frac{1500}{60}\right) = 1{,}904{,}017.212 \quad mm^3/s$$

$$\text{Volume flowrate} = 1.904 \quad L/s$$

with volumetric efficiency $\eta = 90\%$

$$\text{Volume flowrate actual} = 1.904 \times 0.9 = 1.7136 \; L/s$$

If we use second equation:

$$Volume = \frac{\pi}{2}(D_0^2 - A^2) \times (\text{gear width})$$

$$\text{Volume flowrate} = \frac{\pi}{2}(75^2 - 65^2) \times (35) \times \left(\frac{1500}{60}\right) = 1{,}924{,}475 \quad mm^3/s$$

$$\text{Volume flowrate} = 1.924 \quad L/s$$

$$\text{Volume flowrate actual} = 1.924 \times 0.9 = 1.7316 \quad L/s$$

Problem 02

A lobe pump running at 300 rpm, is pumping soybean oil through a 3.0 cm diameter pipe. The pump is driven by a motor that is using 285 Watts. Assuming an overall pump and motor efficiency of 65%, what is the pumping rate if the suction and discharge pressures are -35 and 160 kPa, respectively.

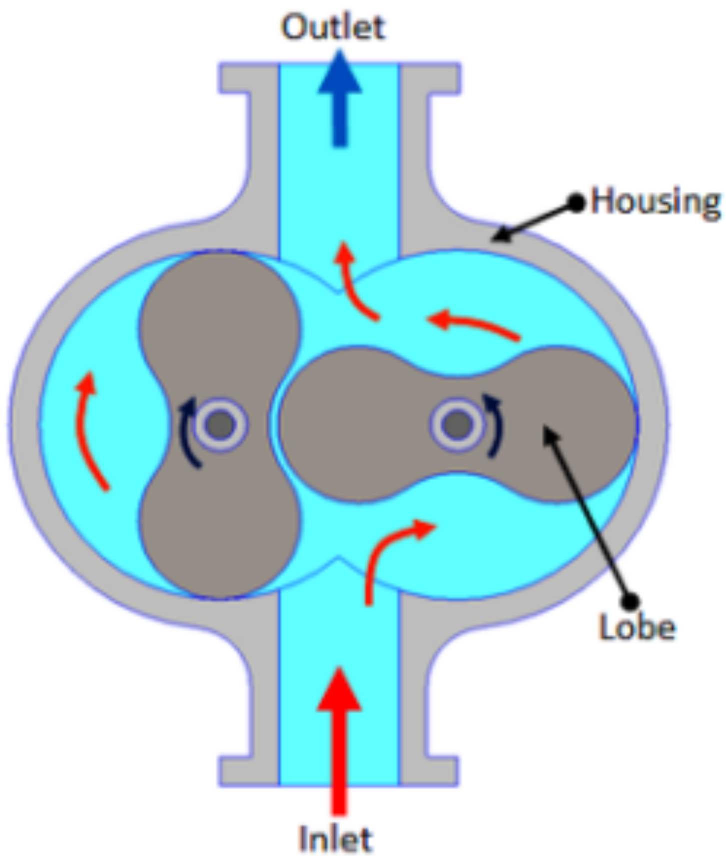
$$Power = \rho g Q h = \rho g h Q = \Delta P \cdot Q = \left(160 - (-35)\right) \times 10^3 \times Q = 195{,}000\mathrm{Q}$$

$$\eta = 0.65 = \frac{195{,}000\mathrm{Q}}{285}$$

$$Q = 0.00095\ m^3/s = 0.95\ L/s$$

Problem 03

A two-lobes rotary positive displacement pump moves 0.60 cm^3 of motor oil in each lobe volume. For every 90° of rotation of the shaft, one lobe volume is pumped. If the rotation rate is 550 rpm, calculate the volume flow rate.



For every 90° of rotation of the shaft, one lobe volume is pumped. For one complete rotation, there is 4 lobe volume has been transferred.

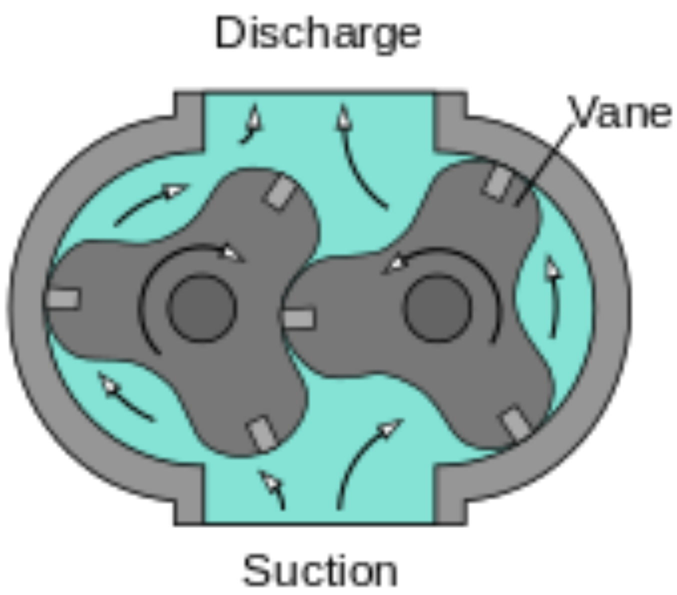
$$V_{closed} = 4 \times V_{lobe} = 4(0.6) = 2.4 \quad cm^3$$

$$Q = \frac{V_{closed}}{rotation} \times (Lobe\ speed)$$

$$Q = \frac{2.4}{1} \times (550) = 1320 \quad cm^3/minute$$

Problem 04

A three-lobes rotary positive displacement pump moves 0.60 cm^3 of motor oil in each lobe volume. For every 60° of rotation of the shaft, one lobe volume is pumped. If the rotation rate is 550 rpm, calculate the volume flow rate.



For every 60° of rotation of the shaft, one lobe volume is pumped. We have 3 lobes.

$$V_{closed} = 6 \times V_{lobe} = 6(0.6) = 3.6 \quad cm^3$$

$$Q = \frac{V_{closed}}{rotation} \times (Lobe\ speed)$$

$$Q = \frac{3.6}{1} \times (550) = 1980 \quad cm^3/minute$$