

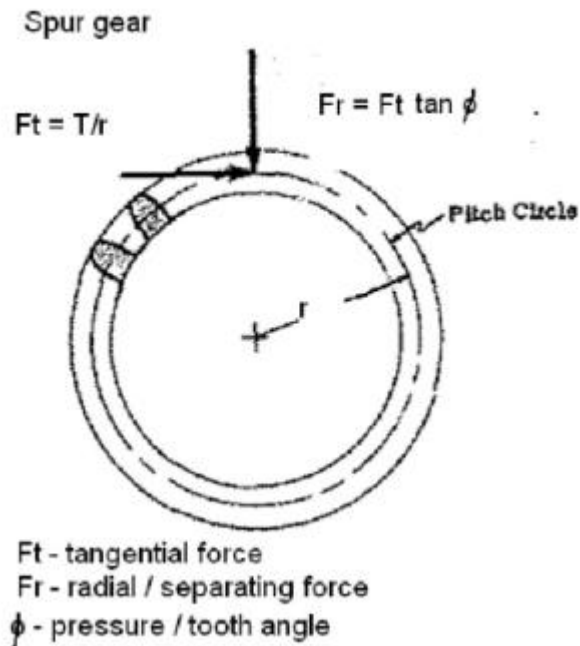
KINEMATICS AND DYNAMICS OF MACHINES

UNIT III NOTES



Forces in Spur Gears

When power is transmitted through a pair of spur gears, forces act between the meshing teeth. These forces are responsible for transmitting torque from the driving gear to the driven gear.



1. Tangential Force (F_t)

- Acts tangentially to the pitch circle.
- Responsible for transmitting power and torque.
- It is the most important force in gear design.

Formula:

$$F_t = \frac{2T}{D}$$

F_t = Tangential force (N)

T = Torque transmitted (N·m)

D = Pitch circle diameter (m)

2. Radial Force (F_r)

- Acts along the line joining the centers of the gears.
- Tends to separate the two gears.
- Produces bearing reactions

Formula:

$$F_r = F_t \tan \phi$$

Where:

- F_r = Radial force (N)
- ϕ = Pressure angle (usually 20°)

3. Normal Force (Fn)

- Acts along the line of action between mating teeth.
- Resultant force from which tangential and radial components are derived.

Formula:

$$F_n = \frac{F_t}{\cos \phi}$$

Where:

- F_n = Normal force (N)

Characteristics of Spur Gear Forces

- Spur gears have **no axial (thrust) force**.
- Only tangential and radial forces act on the gear teeth.
- Bearings must support the radial force.
- Tangential force determines the power-transmitting capacity.

Applications

- Automobile gearboxes
- Machine tools
- Conveyors
- Industrial reducers
- Agricultural machinery

Modeling Gear Assemblies and Animation of Meshing and Load Behaviour

Gear assemblies are used to transmit motion and power between rotating shafts. Modern CAD and simulation software enable engineers to create gear models, assemble them, and visualize gear meshing, load distribution, contact forces, and stress behavior before manufacturing.

Software Used

- SOLIDWORKS
- ANSYS
- Autodesk Inventor
- MSC ADAMS

Procedure

Step 1: Create Gear Models

- Design pinion and gear using standard gear parameters.
- Define:
 - Module
 - Number of teeth
 - Pressure angle
 - Pitch circle diameter

Step 2: Assemble the Gears

- Position gears at the correct center distance.
- Apply gear mates or gear constraints.
- Verify proper tooth engagement.

Step 3: Define Motion Inputs

- Assign rotational speed to the driving gear.
- Set gear ratio according to design requirements.

Step 4: Run Animation

- Simulate gear rotation.
- Observe meshing action and motion transfer.

- Verify smooth engagement of teeth.

Step 5: Apply Loads

- Apply torque or external load to the driven gear.
- Define material properties and contact conditions.

Step 6: Analyze Results

- Contact forces.
- Tooth deformation.
- Stress distribution.
- Angular velocity.
- Torque transmission.

Observations

Gear Meshing Animation

- Continuous engagement and disengagement of teeth.
- Smooth transfer of motion.
- Constant velocity ratio.

Load Behaviour

- Maximum stress occurs near the tooth root.
- Contact pressure develops at tooth surfaces.
- Load is transferred through the line of action.
- Deformation increases with applied load.

Applications

- Automotive transmissions.
- Industrial gearboxes.
- Wind turbines.
- Agricultural machinery.
- Robotics and automation systems.
- Aerospace gear mechanisms.

Parameters Studied

Parameter	Purpose
Angular Velocity	Measure rotational speed
Torque	Determine power transmission
Contact Force	Analyze tooth interaction
Stress Distribution	Predict failure regions
Deformation	Evaluate structural strength
Gear Ratio	Verify motion transmission

Interpreting motion plots and torque-speed curves

Motion plots and torque–speed curves are used to analyze the dynamic performance of gear systems. They provide information about displacement, velocity, acceleration, torque transmission, and power flow during operation.

Definition

Motion plots are graphical representations of motion parameters with respect to time.

Types of Motion Plots

a) Angular Displacement vs Time

- Shows the angular position of a gear at different times.
- The slope of the graph indicates angular velocity.

b) Angular Velocity vs Time

- Shows changes in rotational speed.
- A constant value indicates uniform motion.

c) Angular Acceleration vs Time

- Indicates changes in angular velocity.

- Peaks represent acceleration or deceleration periods

Interpretation

- Smooth curves indicate stable gear operation.
- Sudden fluctuations may indicate vibration, backlash, or misalignment.
- Linear displacement curves indicate constant speed.

Torque–Speed Curves

Definition

A torque–speed curve represents the relationship between transmitted torque and rotational speed.

Power Relationship

$$P = T\omega$$

Where:

- P = Power (W)
- T = Torque (N·m)
- ω = Angular velocity (rad/s)

Interpretation

High-Speed Region

- Speed is high.
- Torque is relatively low.
- Suitable for machine tools and turbines.

High-Torque Region

- Speed is low.
- Torque is high.
- Suitable for conveyors, hoists, and gear reducers.