NVH – Gear Whine Analysis
Gear Whine is a noise phenomenon in transmissions caused by the excitation of the system by Transmission Error at the gear meshes.
NVH Mode

Properties Grid

Load Cases Control

Results Area

Status Area
Modal Analysis

- First we will run a modal analysis
- A modal analysis calculates natural frequencies and mode shapes
- These are dynamic characteristics of the system independent of a forcing function
- Select “Coupled Modal Analysis” at the bottom of the Load Cases Control
Select the “High Speed Cruising” Load Case and click the run button to run the analysis.
Natural Frequencies
Mode Shapes

Select a mode shape to view

Set to view the Linear Displacement as a contour

Set to view the shafts as solid

Scale the deflections in the view

Animate the mode shape
Look at some modes which will be of interest when we run the gear whine analysis:

Mode 11 (1.785 KHz) shows significant kinetic energy in the intermediate shaft and lots of motion at the gear meshes.
Mode 17 (2.609 KHz) similarly shows significant kinetic energy in the intermediate shaft and lots of motion at the gear meshes.
Next we will run a gear whine analysis

A gear whine analysis calculates the forced dynamic response of the system model to excitation by Transmission Error at the gear meshes

Select “Gear Whine/Harmonic Excitation Analysis” at the bottom of the Load Cases Control
Select the “High Speed Cruising” Load Case and click the run button to run the analysis.

An interface appears asking where the Transmission Error is to come from as input. Select “Basic LTCA” for both gear sets. This is the analysis used in the “Cylindrical Gear Micro Geometry” section.
In a gear whine analysis usually the results of interest are on the housing on either

- The housing surface – Leading to airborne noise
- The housing mounts – Leading to structure borne noise

- We have no housing in this MASTA model
- We shall look at the response on the left bearing on the intermediate shaft.
The Dynamic Response Tab shows the response at this bearing to the transmission error excitations.

Set ALL the settings as in the picture.
The Waterfall chart shows the dynamic response as the motor runs up in speed from 0 – 11600 rpm.

The diagonal lines correspond to the frequency of the gear mesh tooth passing order and its harmonics as the motor speed varies.

First Harmonic of the 2nd Gear Stage.
Vertical lines show the natural frequencies

Peaks in response occur at natural frequencies of the system, where excitations frequencies correspond with resonant frequencies

Hovering the mouse over the vertical lines tells you which mode they correspond to

Mode 11 (1.785 KHz)
Mode 17 (2.609 KHz)
As we saw when we looked at the mode shapes these modes have:

- Significant movement at the gear meshes – So can be excited by TE
- Significant strain energy in Intermediate Left Bearing where we are looking at the response
Next task...

- Please now work through the document:

  9. Parametric Study

- The next slide in this document contains some additional tasks you might want to attempt after completing all the other tutorials.
Some additional tasks

1. If you have done the Cylindrical Gear Micro Geometry section change the Micro Geometry Design being used and investigate the effect of transmission error on the Gear Whine Analysis results.

2. Investigate changing the bearings on the intermediate shaft and/or the shaft design and see how it affects the resulting response.