Instability analysis of brake squeal

Introduction

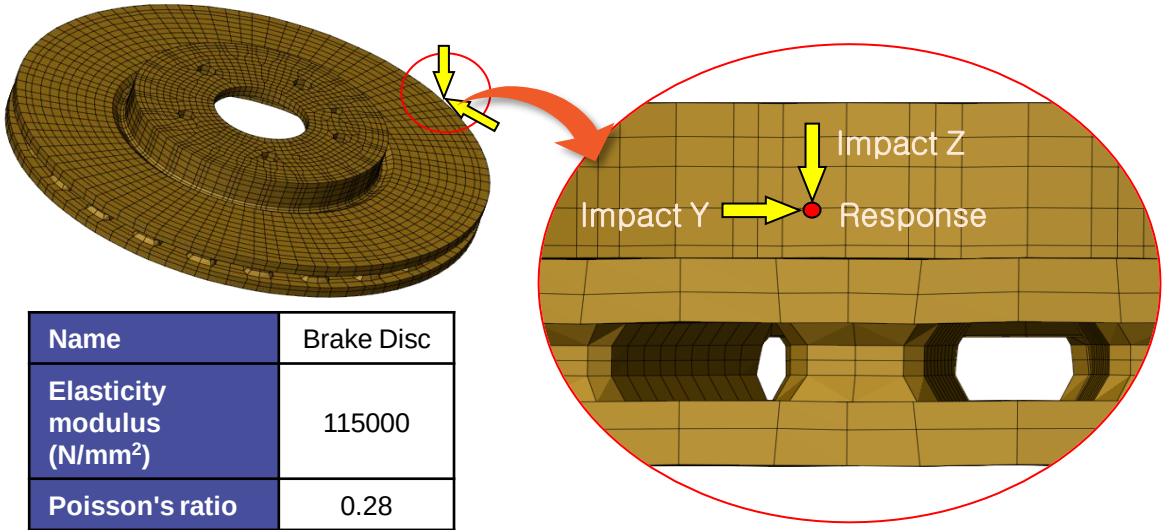
Disc brake, as shown in the above picture is normally a cast iron made wheel brake which slows rotation of the wheel by pressing brake pads against rotating wheel discs. Sometimes high pitched squeal occurs at the end of braking due to vibration of the pads and discs (known as force-coupled excitation). This type of squeal can negatively affect brake stopping performance, needless to say it is annoying to vehicle drivers and passers-by. As vehicle designs become quieter. Noise, and vibration are among the most important priorities for today's vehicle manufacturers.

Accelerometer (response point)

Impact hammer (impact point)

In this case we will perform model analysis and frequency response analysis on brake disk to investigate this kind of problem. Main idea is to separate Out of plane Mode (ND-mode) and In-plane Mode (IPC), which can cause squeal noise.

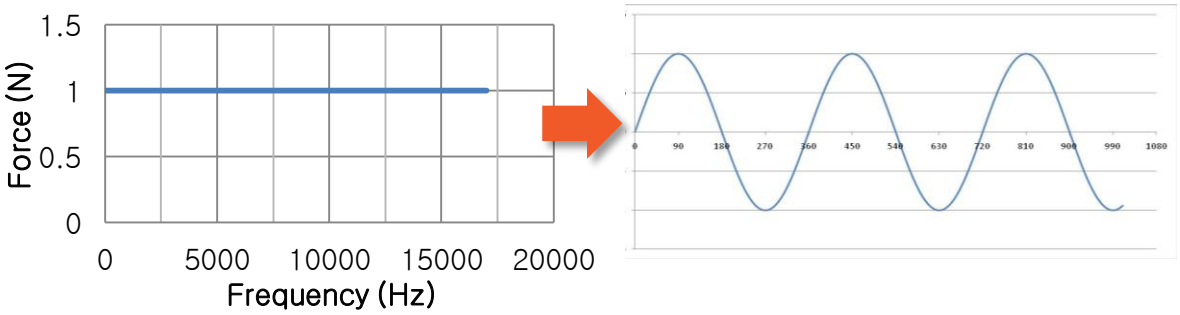
Modeling of brake disk



With the axial and original directions (1N)

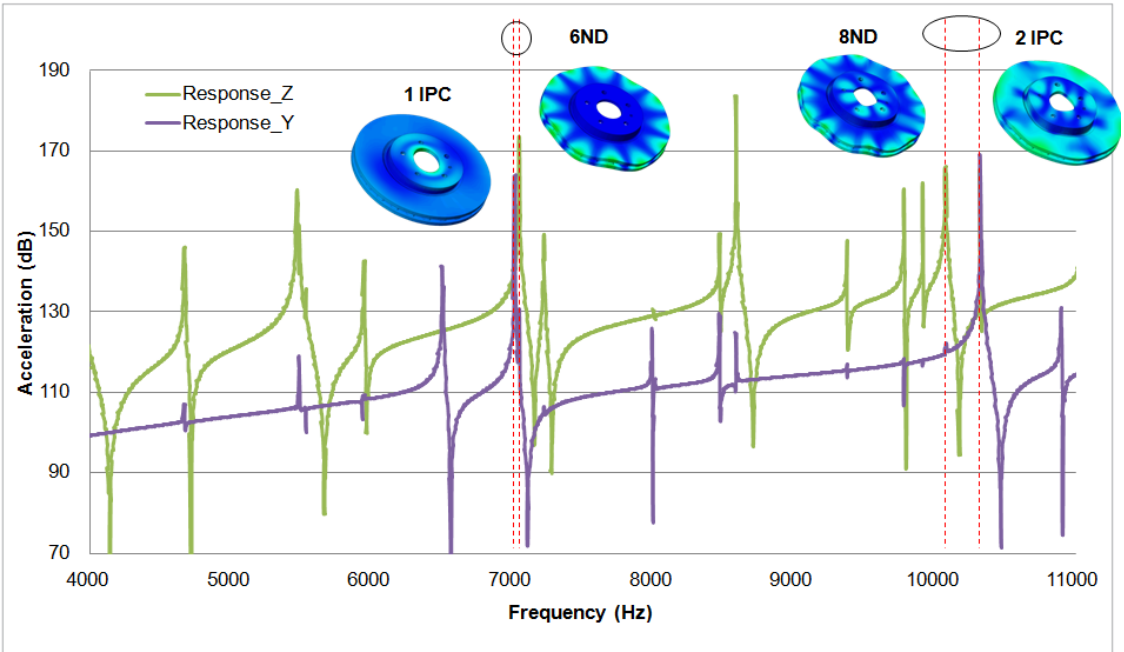
Name	Brake Disc
Elasticity modulus (N/mm^2)	115000
Poisson's ratio	0.28
Density (kg/m^3)	7150

Shown in the above pictures, the finite element model of brake disk contains 14,991 nodes and 10,066 elements. Material is set as cast iron. And



unit load conversed in the form of a sine wave

Frequency response analysis of brake disk

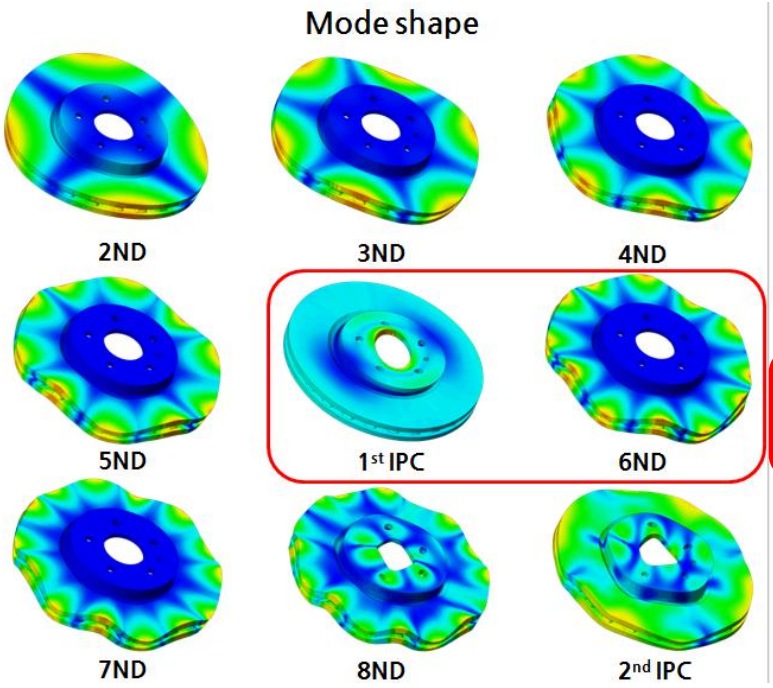


Main cause of squeal noise is indentified as ND mode (Nodal Diameter Mode) and IPC mode (In-Plane Compression Mode). ND mode is when disk shake up and down, while IPC mode is when squeezing force applied to the same side to make the disk deform.

When the frequency of 2 modes are close to each other, squeal noise is more likely to occur. By applying frequency response analysis in the early stage of product development, we can separate frequencies of 2 modes by optimizing the disk design.

The analysis is performed by midas NFX frequency response analysis, from the results, we can observe that around 7000Hz, frequencies of two modes are very close, where squeal noise is most likely to occur.

Mode analysis of brake disk



Mode	Natural frequency
2ND	1027 Hz
3ND	2394 Hz
4ND	3897 Hz
5ND	5468 Hz
1st IPC	7014 Hz
6ND	7045 Hz
7ND	8592 Hz
8ND	10068 Hz
2nd IPC	10285 Hz

Above results are performed by midas NFX mode analysis. From the result we can see that frequency difference bewteen1st IPC mode and 6th ND mode is only 30Hz. The difference is too small and squeal noise is highly possible to occur. Therefore a design modification is in need for the above case.