Damping in Roller Bearings

### Damping

**Sources of Damping**

1. Damping of the EHD (elastohydrodynamic) film in the contact region between roller and race
2. Interface damping between the bearing races and mounting structure and shaft
3. Damping due to lubricant squeezing within the inlet region of the Hertzian contact
4. Material damping of rollers and raceways from Hertzian contact deformation

Vibration transfer through a roller bearing is influenced by the stiffness and damping behaviour of the contacts between rolling elements and raceways.

Damping within a rolling element baring arises from a variety of sources. Assuming a dry ball bearing, material damping as a result of asperity contact, frictional damping, and dissipative losses at interfaces can equate to a damping coefficient of 1% [1]**.** The addition of lubricant can introduce EHL film damping effect which can equate to a damping ratio of 2%. Increasing contact area, i.e., more elements, larger element size and type of element also increases the damping ratio. Dietl et. al found that within a tapered roller bearing, as speed increased above 2 000 rpm, the EHL damping ratio began to level at around 4%, with an additional 1% arising from material damping.

Damping coefficient can be obtained as a factor of contact stiffness. This is beneficial to the numerical convergence of the model in the initial stages when the system is released from stationary. The following relationship is used to find the coefficient, :

where K is the contact stiffness, and the damping factor, , is in the range of as reported by Krämer [2].

**Frequency dependency on damping**

**Damping of dry, lubricant-free bearing**

Material and frictional damping due to asperity contact are present in roller bearings. These can be approximated by using a material damping matrix :

where is the bearing stiffness matrix, is the vibration frequency, and is the loss factor (the same as from SKF theoretical approach) which is a common approach used in material damping theory [1][3]. The loss factor is determined using experimental analysis. Loss factor is also related to modal damping ratio, , by the relationship:

**Theoretical Approach – SKF**

For a dry (lubricant-free) bearing, the minimum damping ability can be estimated with fair accuracy using a loss factor. This is a common technique used in material damping theory [3]. The empirical approach uses the following equation:

This simple relationship provides a relationship between the damping coefficient, , the bearing stiffness coefficient, , and the vibration frequency, . represents the energy dissipated per load cycle, and represents the maximum energy due to elastic deformation. Loss factors are obtained through experimentation.

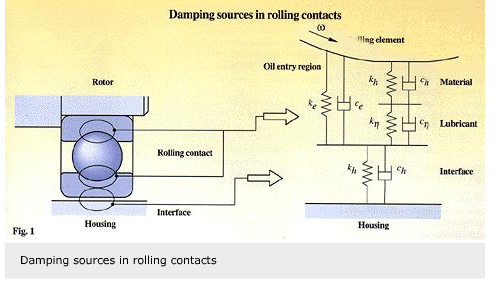


Figure - Damping sources in rolling contacts – SKF

### Damping

Vibration transfer through a roller bearing is influenced by the stiffness and damping behaviour of the contacts between rolling elements and raceways.

Damping within a rolling element baring arises from a variety of sources. Assuming a dry ball bearing, material damping as a result of asperity contact, frictional damping, and dissipative losses at interfaces can equate to a damping coefficient of 1% [12]**.** The addition of lubricant can introduce EHL film damping effect which can equate to a damping ratio of 2%. Increasing contact area, i.e., more elements, larger element size and type of element also increases the damping ratio. Dietl et. al found that within a tapered roller bearing, as speed increased above 2 000 rpm, the EHL damping ratio began to level at around 4%, with an additional 1% arising from material damping.

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| --- | --- |
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|  |  |
| --- | --- |
|  | [18] |

The contact damping force for each element, , is split into and components, and subtracted from the element reaction force.

[1] P. Dietl, J. Wensing, and G. C. Van Nijen, “Rolling bearing damping for dynamic analysis of multi-body systems - Experimental and theoretical results,” *Proc. Inst. Mech. Eng. Part K J. Multi-body Dyn.*, vol. 214, no. 1, pp. 33–43, 2000, doi: 10.1243/1464419001544124.

[2] E. Krämer, *Dynamics of Rotors and Foundations*. Berlin, Heidelberg: Springer Berlin Heidelberg, 1993.

[3] B. J. Lazan, *Damping of Materials and Members in Structural Mechanics*. Oxford: Pergamon Press, 1968.