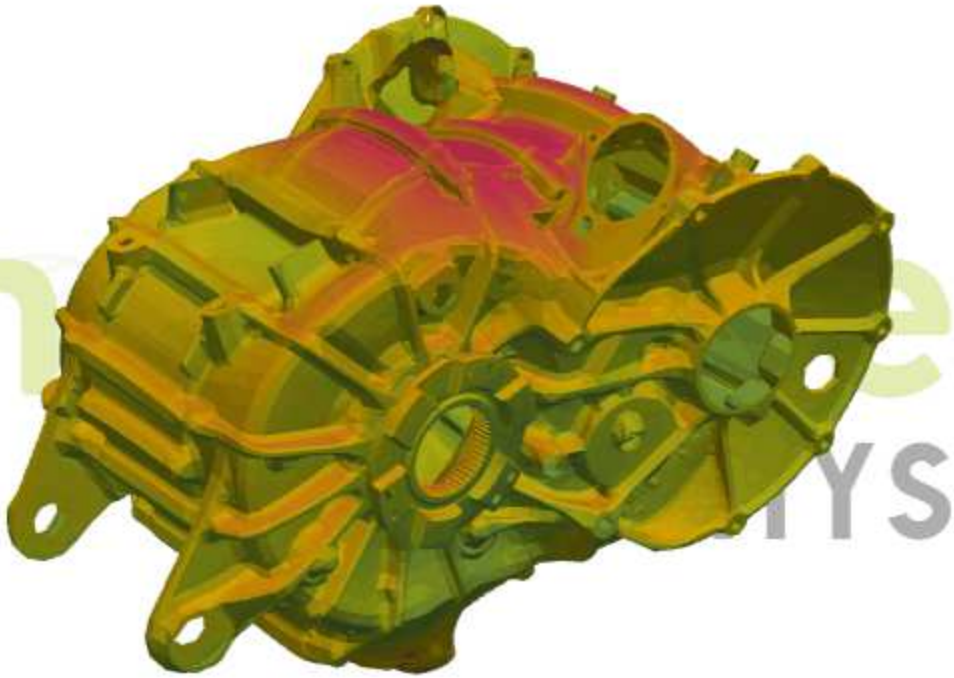
10 Common Misconceptions on Magnetic Noise & Vibrations (e-NVH)



Illustrated with Manatee e-NVH CAE collaborative platform developed by EOMYS

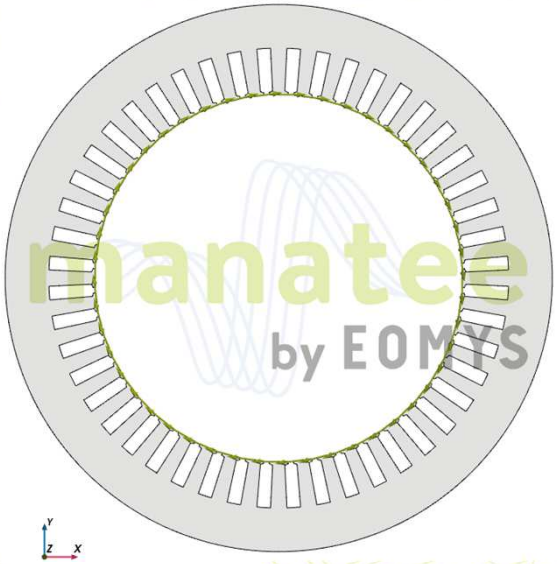
www.e-nvh.eomys.com

#1 « Magnetic noise and vibrations comes from torque ripple »

Torque ripple is generated by a ***small fraction of magnetic force harmonics*** *(wavenumber r=0, tangential direction). Significant e-NVH levels can be produced by* ***radial forces.***

Besides, ***peak to peak metrics are not suitable*** *for e-NVH as they combine phase information of different harmonics.*

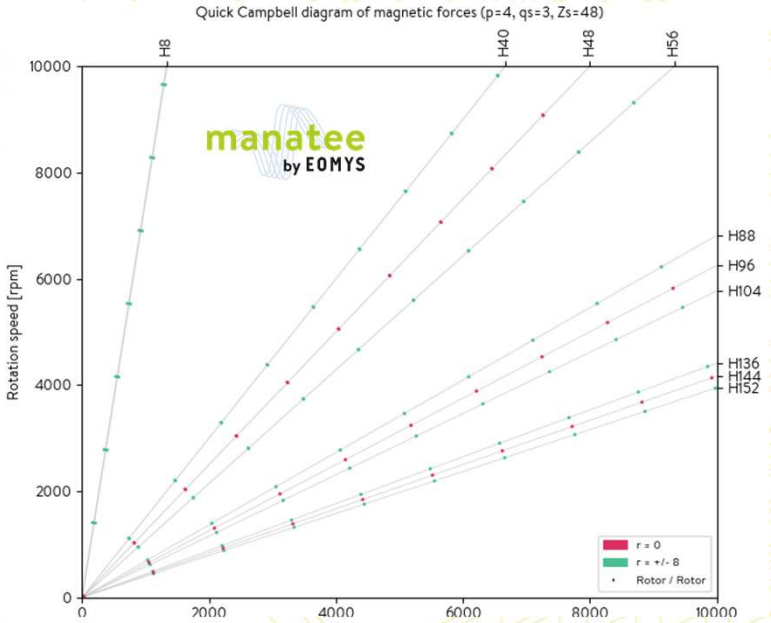
There is ***no general correlation between e-NVH and torque ripple levels*** *according to EOMYS experience.*



#2 « e-NVH problems can be avoided by choosing the right slot/pole combination »

*Slot/pole combination gives an idea of the **structure of the magnetic force spectrum**, but for a same slot/pole combination quiet and noisy machines can be designed.*

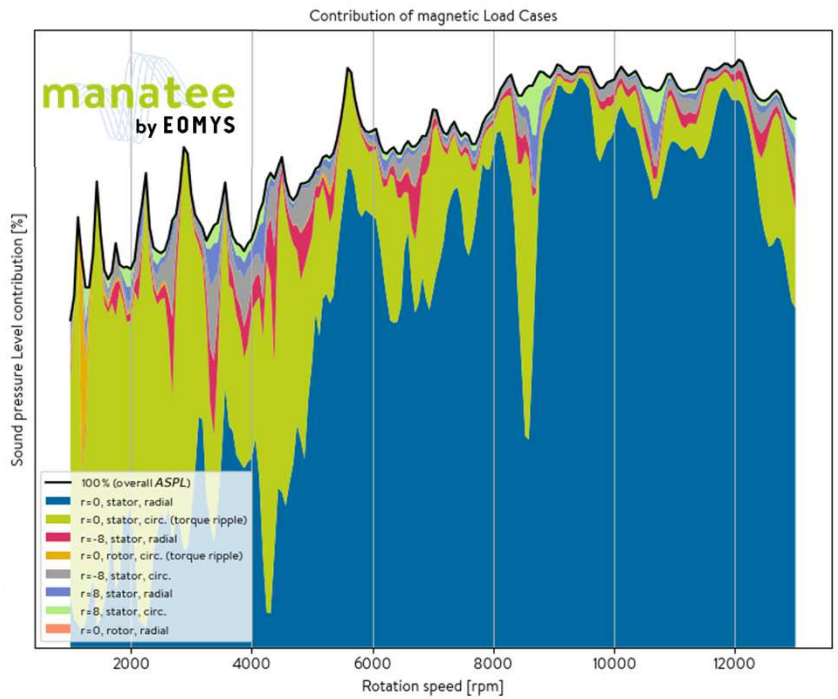
*e-NVH level is influenced by stator/rotor natural frequencies so **there can't exist a « quiet » slot/pole combination.***



#3 « Airborne noise is produced by radial magnetic forces»

Stator ***normal deflections can be produced by tangential forces*** *of positive wavenumbers. In some slot/pole combinations, tangential forces may produce as much airborne noise as radial forces.*

Torsional forces applied to external stator may induced ***bending deflections*** *suitable to produce significant* ***airborne noise.***



#4 « Excitations can be analyzed through Maxwell stress harmonics wavenumber and frequencies »

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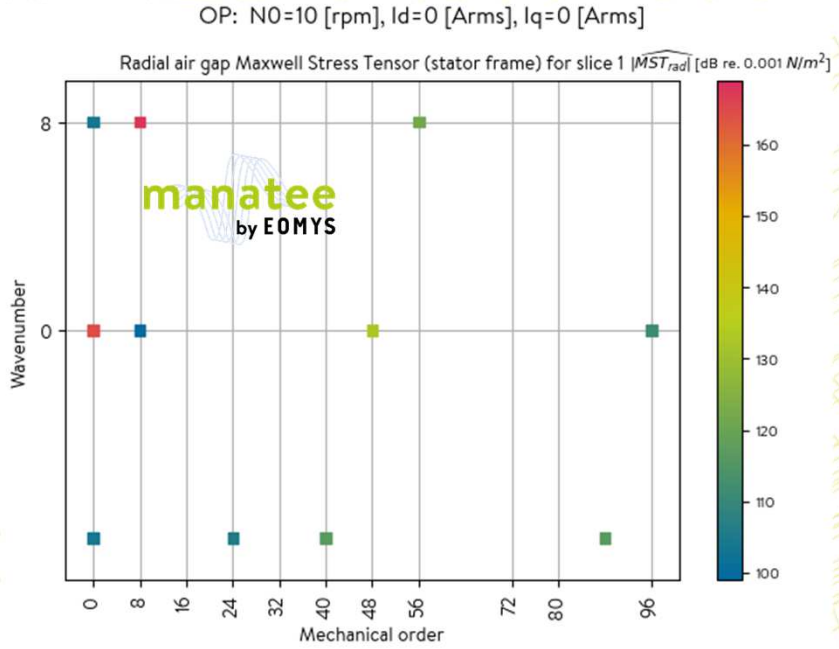
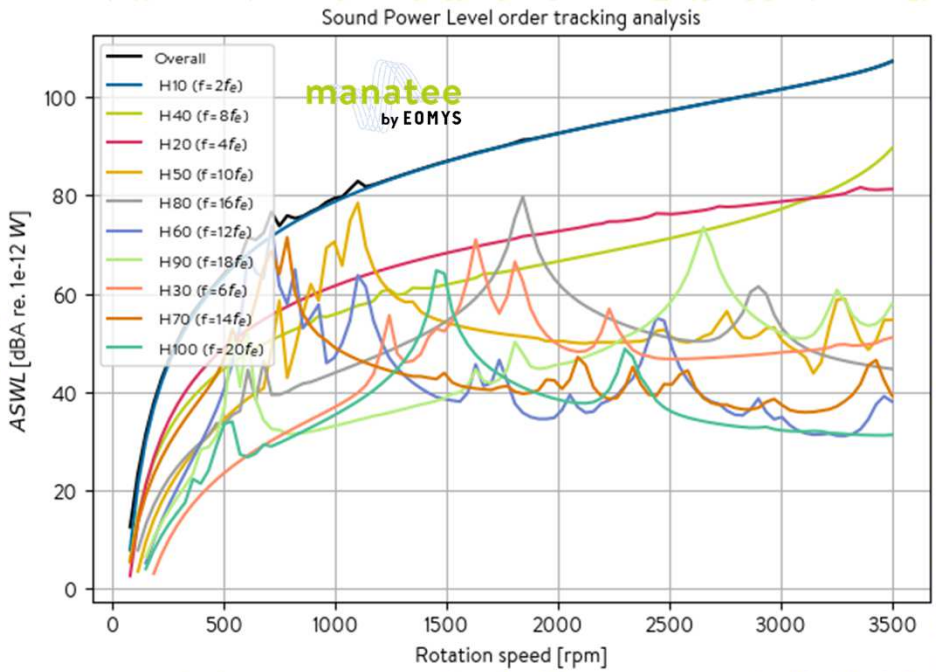


#5 « High magnetic noise level comes from resonances between magnetic forces and structural modes »

Significant levels of magnetic noise and vibrations can be produced by ***forced excitation regime****, in particular due to fundamental force at twice the electrical frequency.*

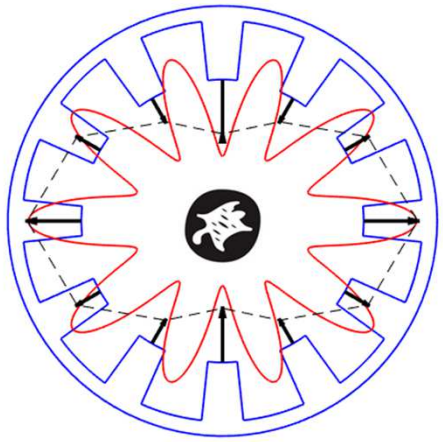
Switching noise can also produce significant noise without any particular resonance.



#6 « High e-NVH levels come from Maxwell stress harmonics with low wavenumber »

Maxwell stress harmonics are not physical local forces, they can only be used to reflect global forces (e.g. torque, UMP). It should therefore be analyzed carefully.

*A **modulation effect** occurs when going from Maxwell stress to physical, local forces observed by stator teeth (« lumped forces »). This modulation effect may **convert high wavenumber Maxwell stress harmonics into low wavenumber lumped forces.***



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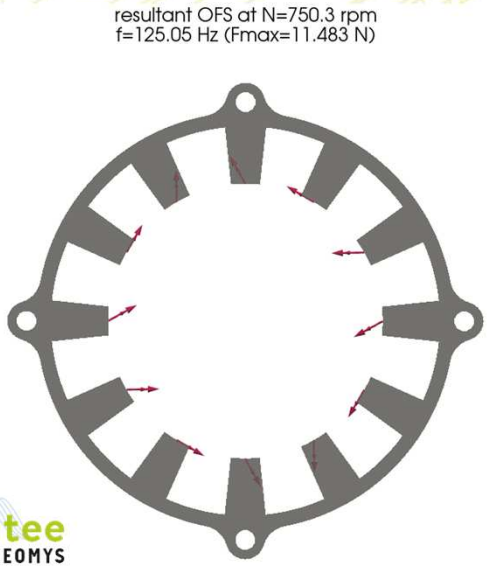
#7 « Lowest wavenumber of magnetic forces is given by GCD(Zs,2p) in PMSM»

This formula on Greatest Common Divider is only true in ***open circuit, symmetrical machine*** *(no eccentricity, no uneven airgap, no uneven magnetization) and holds for* ***Maxwell stress harmonics****, not physical harmonics observed by stator teeth.*

Under load the formula is more complex as it depends on winding pattern. Wavenumbers of stator lumped forces include a ***modulation effect*** *which is not taken into account in this formula.*



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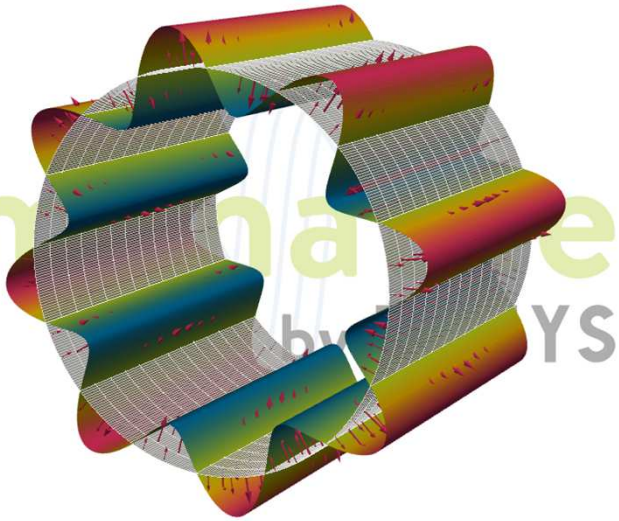
#8 « Magnetic noise and vibrations are produced by low wavenumber forces »

« Low » wavenumber forces ***depends on the shape ratio of the lamination****. In large electrical machines, EOMYS observed high magnetic noise levels with wavenumber r=27.*

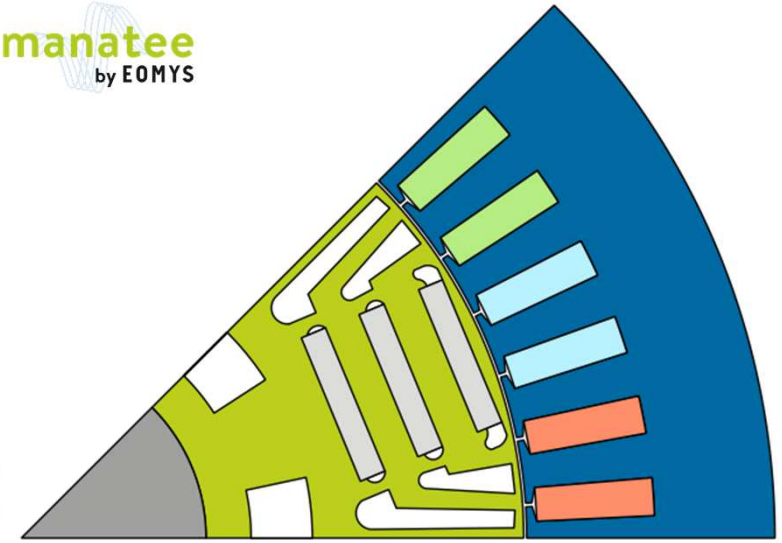
High vibration levels can be produced by high wavenumber forces due to ***fundamental field*** *(e.g. r=2p=8 in a 8-pole traction IPMSM).*



#9 « Closing the slot reduces magnetic noise and vibration »

Magnetic noise may not be produced by slotting effect. Some electromagnetic excitations come from ***fundamental field or winding harmonics****, which are independent of slotting effects.*

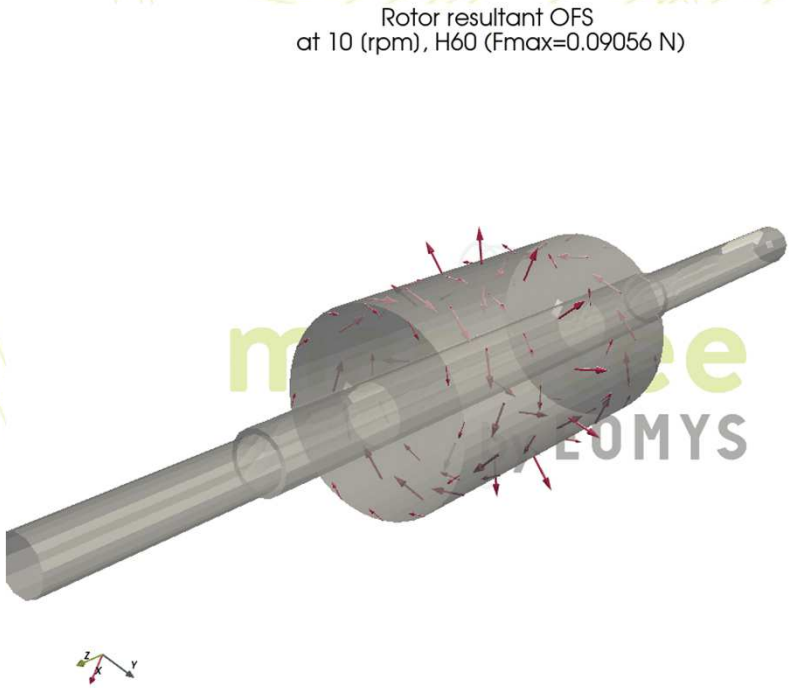
The decrease of slotting excitations with slot opening reduction is limited by ***magnetic staturation****. Besides, somes induction machine may show lower noise level when* ***increasing slot opening*** *depending on the initial design.*



#10 « Skewing reduces magnetic noise and vibration levels »

Skewing can increase the noise level due to magnetic forces. This may be due to side effects such as ***axial forces****, or* ***excitation of longitudinal modes*** *due to force variations along the axis.*

There can be different optimum skew angles to reduce cogging torque, torque ripple and magnetic noise.



Interested in learning more about e-NVH?

Next webinar on Manatee e-NVH software
planned 20th April 2023
https://manatee.eomys.com/manatee-webinars/

Next technical training on e-NVH
planned 23-25th May 2023 at EOMYS office
https://www.training.eomys.com/