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Mon-Mo-Po1.07-07 [82]: Stator MMF Equation of Three-phase Motor Considering Sub-Harmonics for Analyzing Electromagnetic Vibration

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Generally, when designing an electric device, the harmonic components in the electric angle of the MMF do not generate the average torque, so only the fundamental component in the electric angle is considered. Also, the back EMF and the torque ripple include only the harmonic components based on the electric angle. Therefore, the conventional MMF wave equation considers only the harmonic components based on the electric angle.
Conventional equations are not problematic in obtaining electromagnetic characteristics such as back EMF, torque, and torque ripple generated by electric machines. However, the distribution of radial force density, which is the cause of electromagnetic vibration of electric machines, also generates sub harmonics in addition to the fundamental component of electric angle depending on the combination of poles and slots. Therefore, in order to consider the electromagnetic vibration characteristics, the harmonic components of the MMF waveform based on the machine angle, not the electrical angle, should be considered.
For example, consider the stator MMF of the 8 pole 9 slot motor. Using the conventional equation, the spatial harmonic component of the air gap MMF waveform generated by a single-phase winding can be obtained only in the 1st, 3rd, 5th and 7th components of the electrical angle shown in black. This means that only the 4th, 12th, 20th, and 28th harmonic components of the mechanical angle can be calculated, and it is difficult to calculate the remaining sub harmonics, so that the electromagnetic vibration of the electric machine cannot be accurately predicted.
In this paper, we propose a generalized three-phase stator three-phase winding equation that can accurately calculate the spatial distribution of stator MMF for all combinations of poles and slots.
To verify the equation proposed, the magnetic flux density of the 8p9s and the 8p48s models was calculated by FEM and the proposed equation.

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