

Abstract

- The effect of rotor eccentricity in the no-load and load conditions on the distributions of electromagnetic force in the HSPM generator is studied and the allowed tolerance of rotor eccentricity is determined.
- The current harmonics generated by the rectifier are injected into the generator armature to study the distribution of core loss, eddy current loss, and temperature rise (particularly on the rotor).
- The resonance impact of rotor eccentricity and current harmonics on the electromagnetic force distribution is also evaluated.
- The results show that the increase of losses, temperature, vibration, and mechanical strength in HSPMG depends on the amplitude and percentage of total current harmonic distortion injected into the HSPMG under an allowable rotor eccentricity.

Methodology Analysis

- Evaluation of electromagnetic force in the HSPM generator under the impact of current harmonics and rotor eccentricity.
- Evaluation of the losses and thermal in the HSPM generator under the impact of current harmonics.

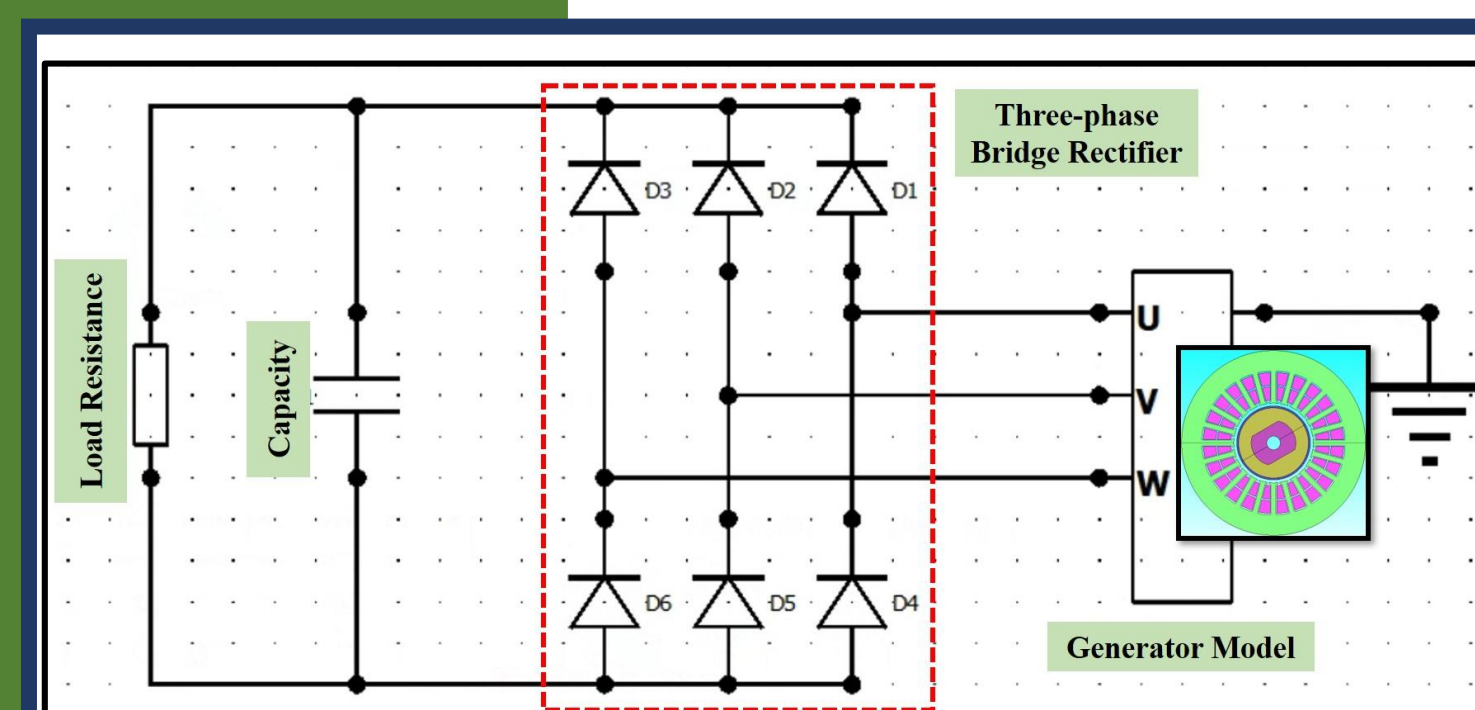


Fig. 1. Model of 200 kW 45000 rpm HSPM generator with the rectifier for study

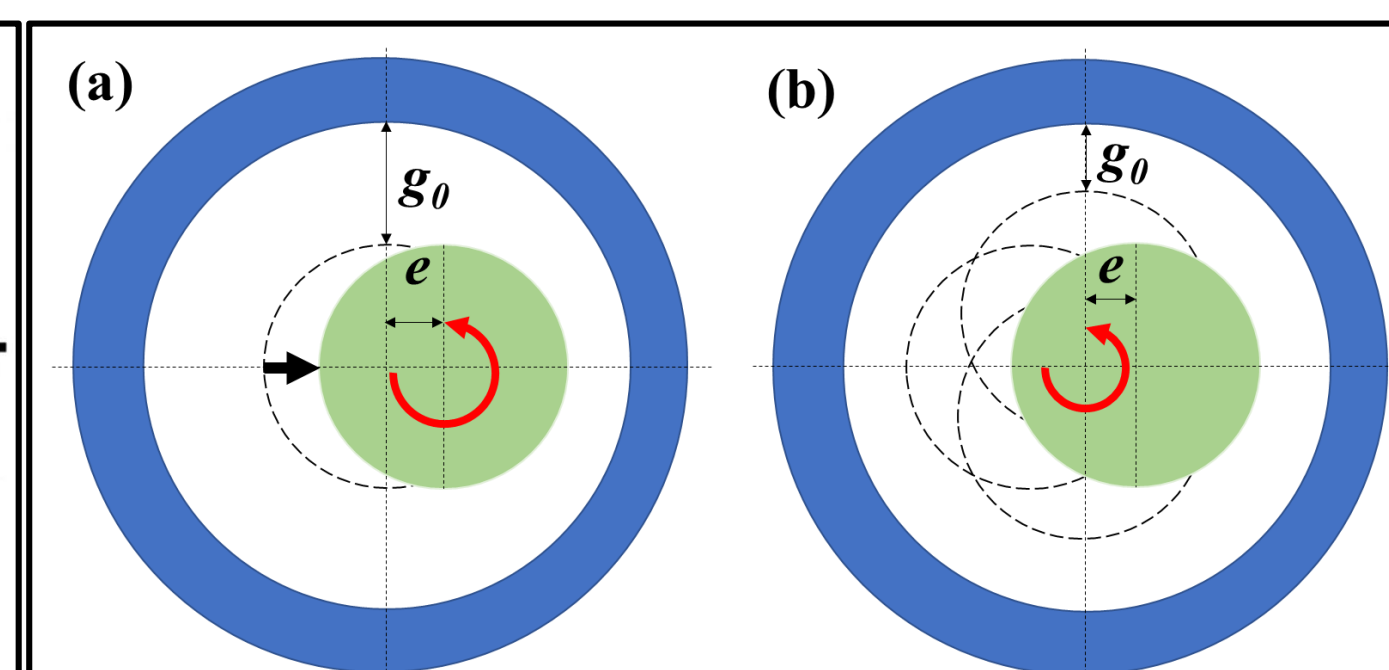


Fig. 2. Schematic design of eccentricity for study. (a) Static eccentricity, (b) Dynamic eccentricity.

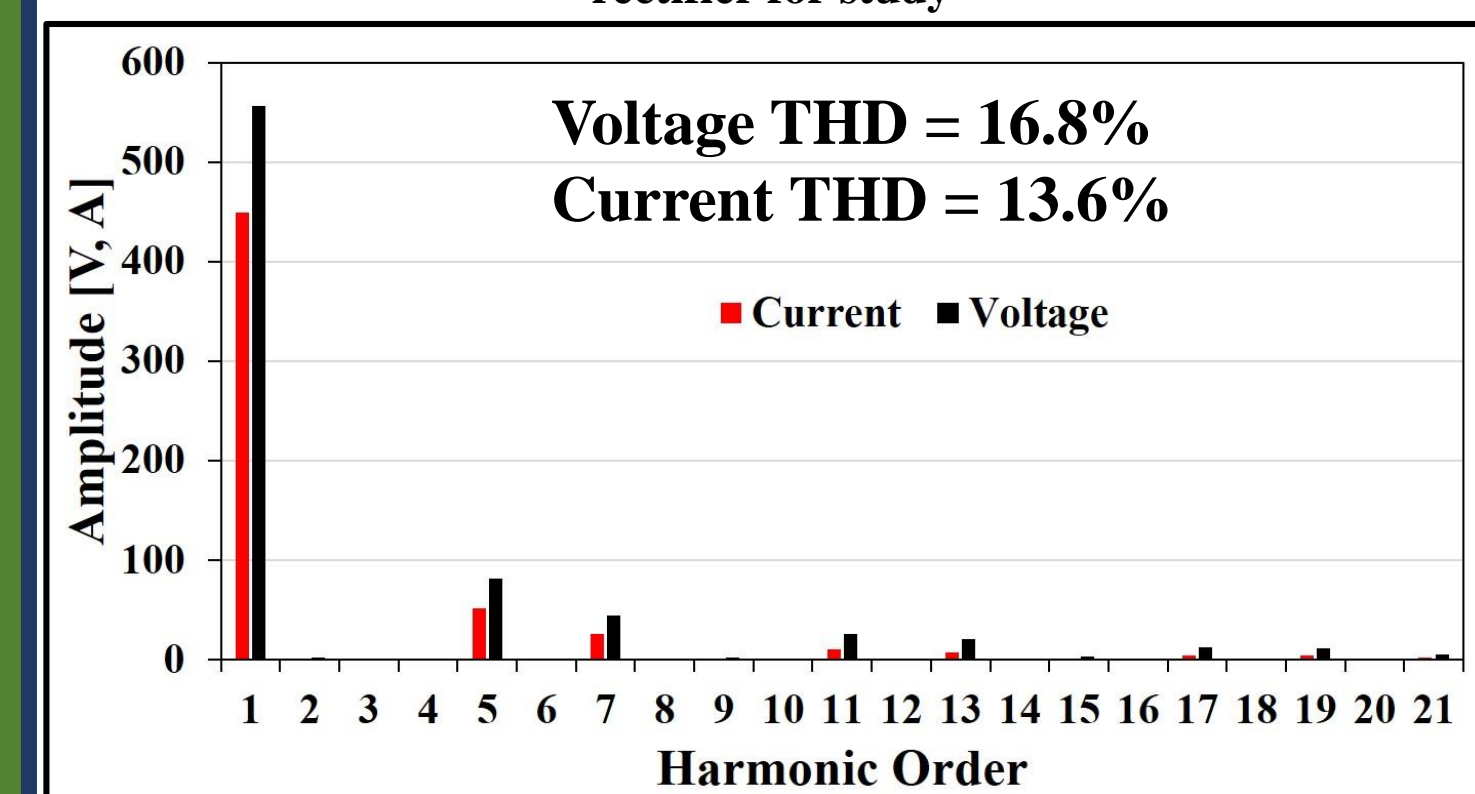


Fig. 3. Total harmonic distortion of voltage and current under the effect of rectifiers

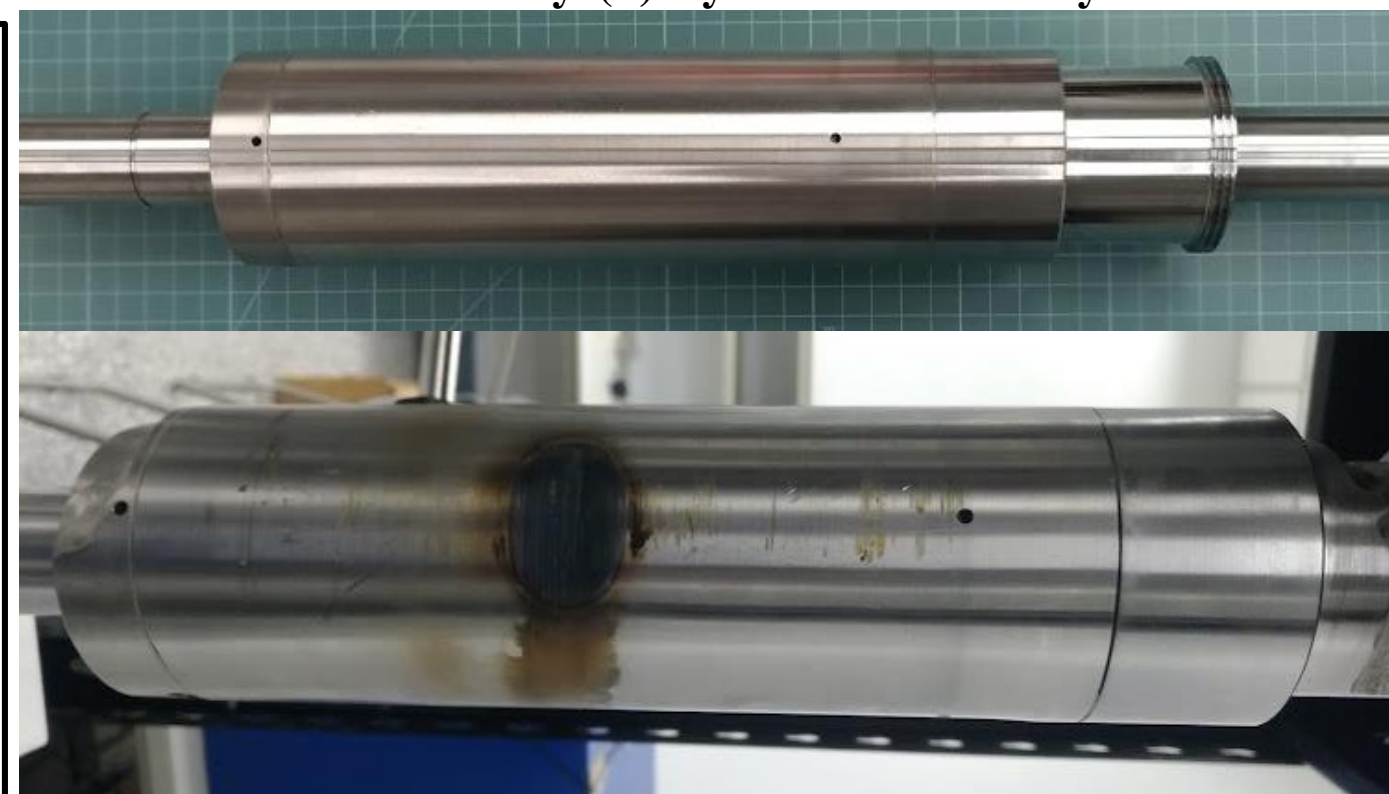


Fig. 4. Rotor prototype of HSPM generator broken at 30000 rpm

Effect of Harmonics on Generator Losses

The voltage and current harmonics significantly increase the total loss on HSPM generator

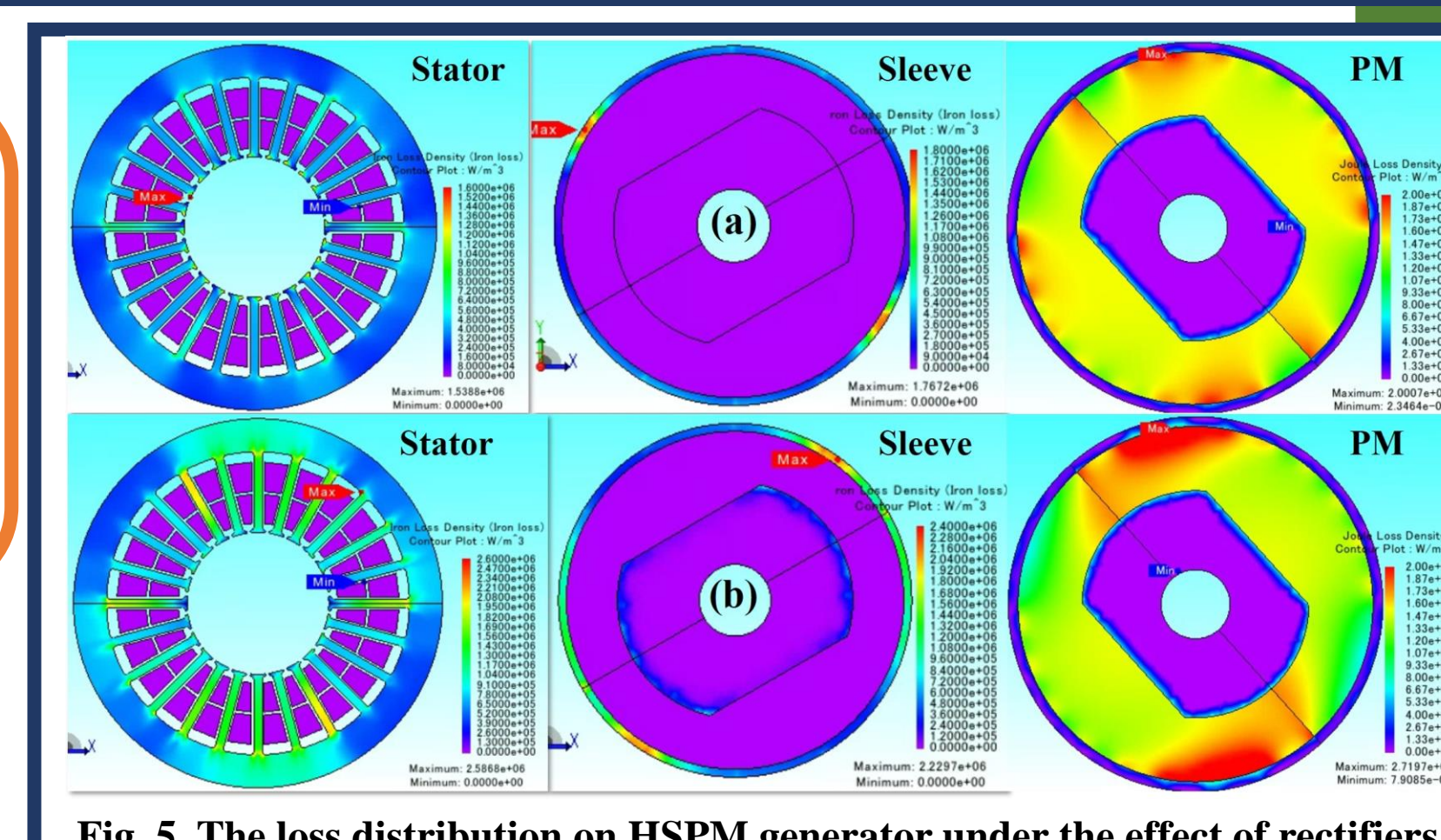


Fig. 5. The loss distribution on HSPM generator under the effect of rectifiers

Effect of Harmonic on Stator and Rotor Forces

The distribution of electromagnetic force on the stator and rotor of HSPM generator slightly increases under the effect of voltage and current harmonics.

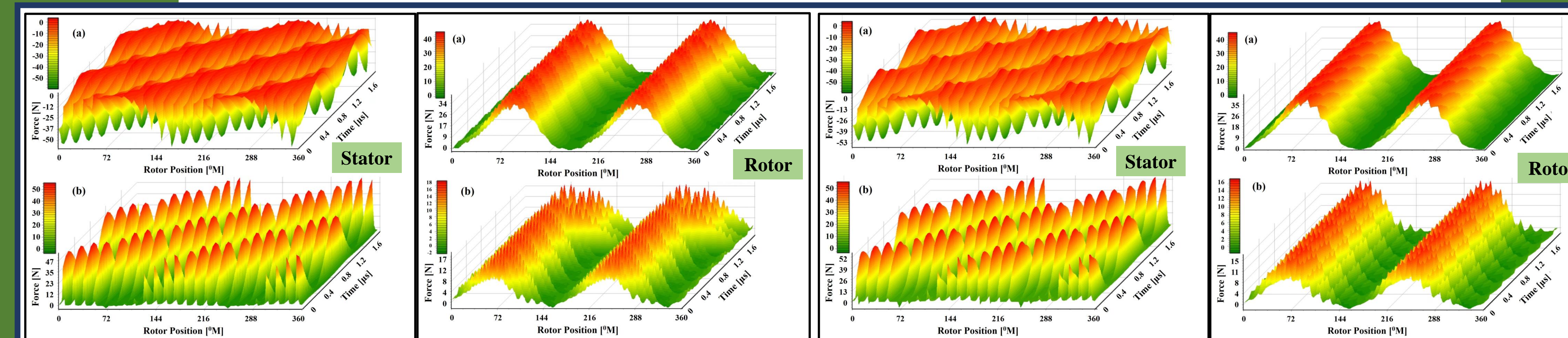


Fig. 6. The distribution of electromagnetic force on the stator and rotor of HSPM generator without the effect of voltage and current harmonics: (a) Radial force, (b) Tangential force.

Fig. 7. The distribution of electromagnetic force on the stator and rotor of HSPM generator with the effect of voltage and current harmonics: (a) Radial force, (b) Tangential force.

Effect of Eccentricity and Harmonic on Stator and Rotor Forces

The distribution of electromagnetic force on the stator and rotor of HSPM generator significantly increases under the effect of rotor eccentricity, voltage and current harmonics.

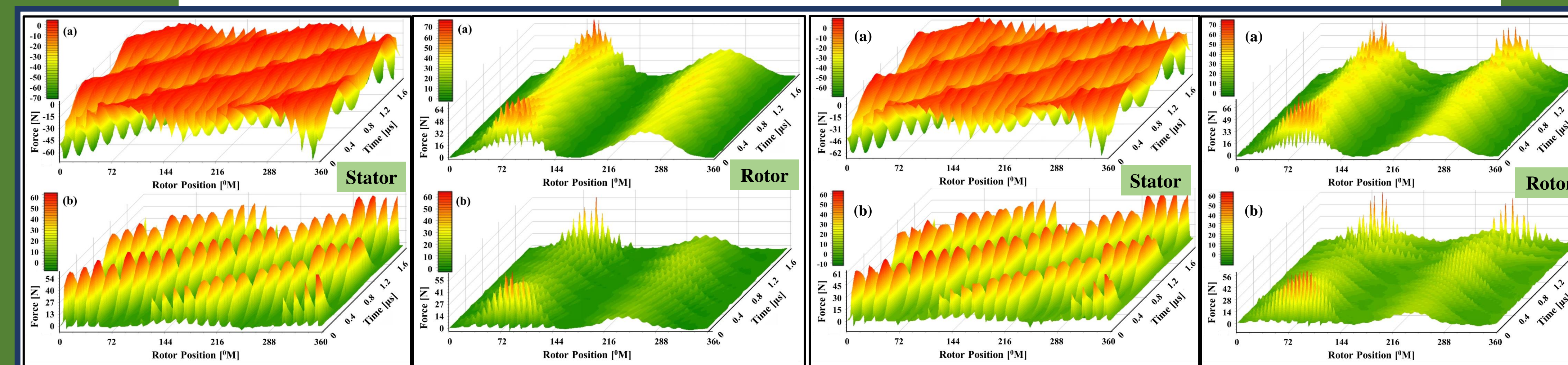


Fig. 8. The distribution of electromagnetic force on the stator and rotor of HSPM generator with the effect of 20% rotor eccentricity: (a) Radial force, (b) Tangential force.

Fig. 9. The distribution of electromagnetic force on the stator and rotor of HSPM generator with the effect of 20% rotor eccentricity, voltage and current harmonics: (a) Radial force, (b) Tangential force.

Effect of Harmonics on Thermal

The temperature on the rotor core of HSPM generator increases about three times under the effect of voltage and current harmonics.

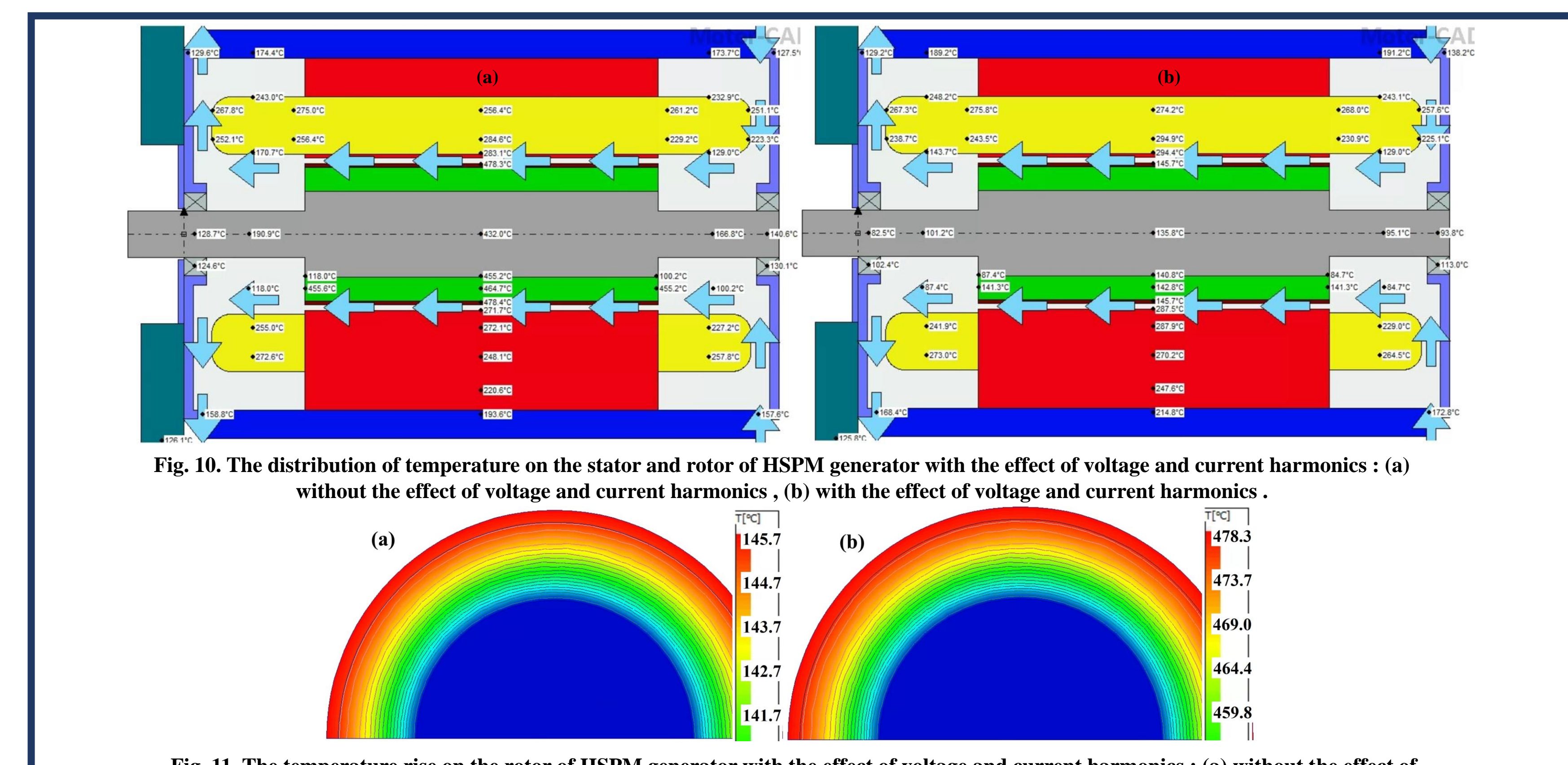


Fig. 10. The distribution of temperature on the stator and rotor of HSPM generator with the effect of voltage and current harmonics : (a) without the effect of voltage and current harmonics , (b) with the effect of voltage and current harmonics .

Fig. 11. The temperature rise on the rotor of HSPM generator with the effect of voltage and current harmonics : (a) without the effect of voltage and current harmonics , (b) with the effect of voltage and current harmonics .

Effect of Eccentricity and Harmonic on Mechanical Strength

- The rotor expansion increases to 40% with the effect of rotor eccentricity, voltage, and current harmonics when the rotor eccentricity is 50%.
- The rotor stress increases to 70% with the effect of rotor eccentricity, voltage, and current harmonics when the rotor eccentricity is 50%.

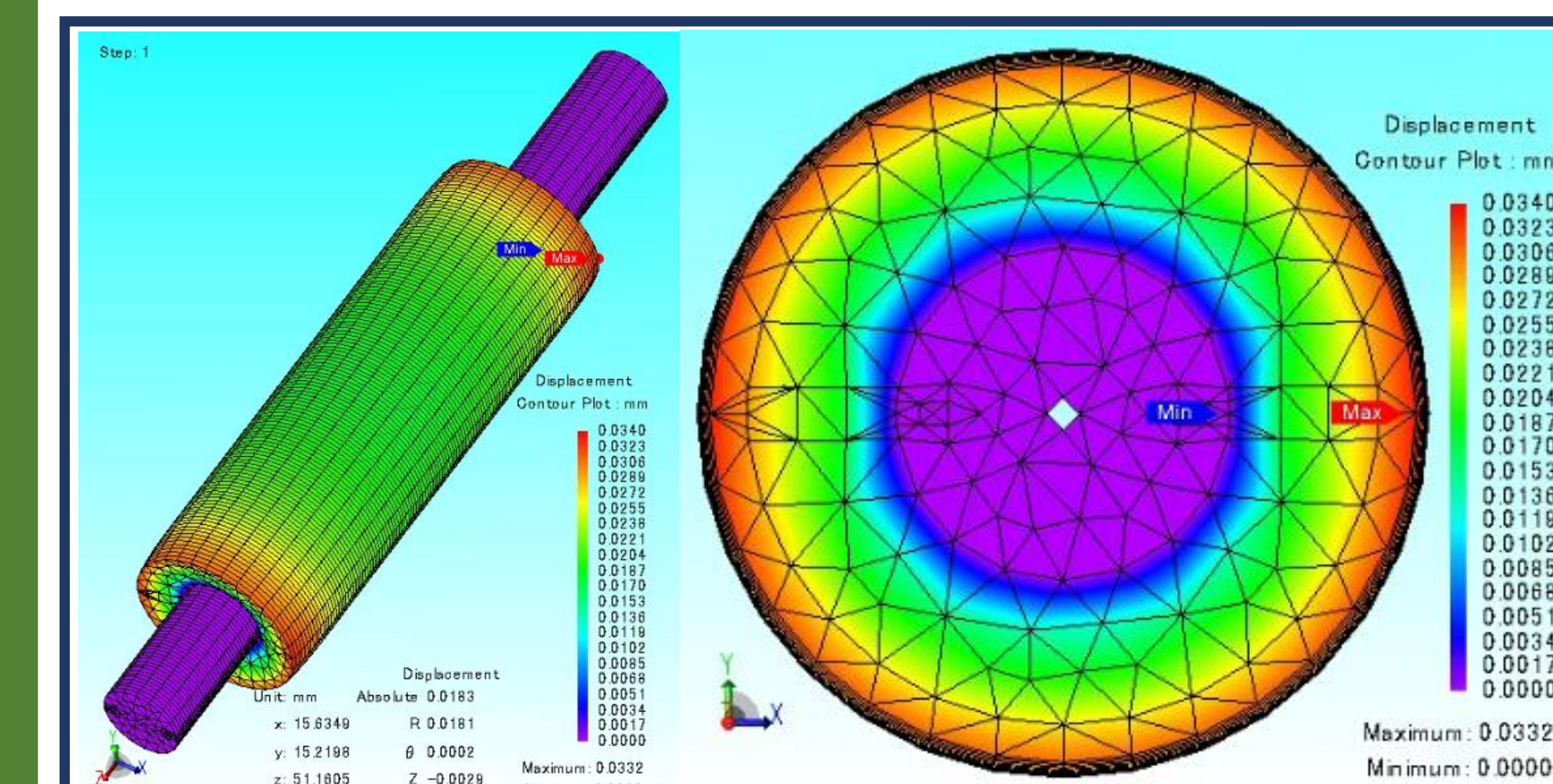


Fig. 12 The maximum rotor expansion at 45000 rpm under the effect of eccentricity and harmonics

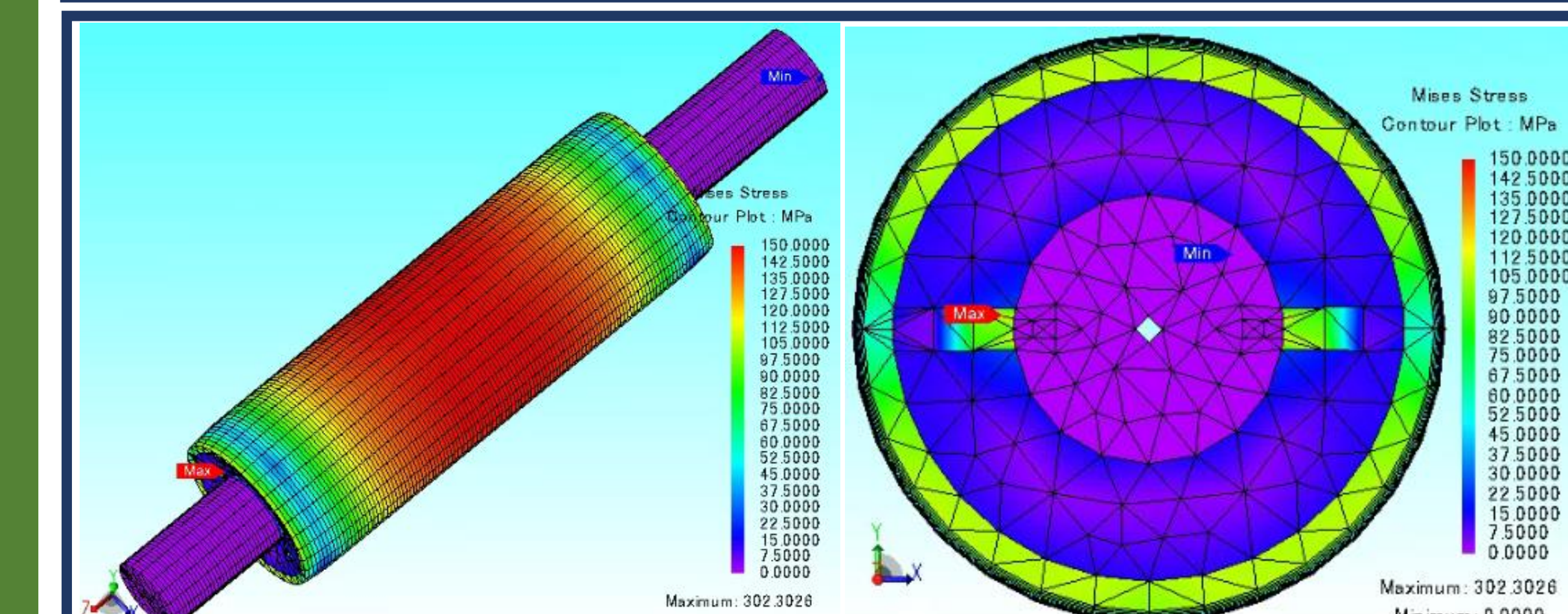


Fig. 13 The maximum rotor stress at 45000 rpm under the effect of eccentricity and harmonics

Conclusions

- This effect of rotor eccentricity and current harmonics on the performance of an HSPM generator has been analyzed.
- The results show that the iron loss and temperature of the generator are worsened with the effect of voltage and current harmonics.
- The impact of rotor eccentricity and harmonics on the mechanical strength of the rotor core of the HSPM generator is significant. That is why the rotor core has been broken after operating at the speed of 30000 rpm.

Acknowledgments: This work is supported by the Ministry of Science and Technology, Taiwan, under contract 108-2622-8-006-014 and by Southern Taiwan Science Park Bureau under contract 106GF02. The assistance of Mr. C.-Y. Chang and J.-Y. Huang in tests is appreciated. JSOL and ANSYS Taiwan are acknowledged for supporting JMAG and MotorLAB.