MT 26 International Conference on Magnet Technology Vancouver, Canada | 2019

Experimental Characterization of a No-insolation HTS Racetrack Coil Subjected to Travelling Magnetic Fields

Kang Liu [1], Shuai Xu [1], Zhengwei Zhao [1], Zhenyao Sun [1], Pengbo Zhou [1], Le Han [1], Liangyu Bai [2] , Jing Li [1] and Guangtong Ma [1]
1-Applied Superconductivity Lab., State Key Lab. of Traction Power, Southwest Jiaotong University, Chengdu, China.
2-Technology and Engineering Center for Space Utilization, Chinese Academy of Sciences, Beijing, China.
E-mail: gtma@swjtu.edu.cn, kangliujd@163.com

Introduction

The application of high temperature superconducting (HTS) coated tapes in electromagnets showed its great promises in high performance linear synchronous motors (LSM). Due to its ideal current capacity of the conductor, the HTS LSM would be more efficient and the structure is much compact. With the development of no-insulation (NI) coil winding method, HTS coated coil which is fabricated without insulation material between the layers demonstrates its better application prospect in LSM. The contact between the turn to turn layers would provide the HTS magnet with better performance when local quench occurs.

Generally, the HTS magnets have to work in the travelling magnetic field with a synchronous moving speed. However, the travelling magnetic field of the LSM is inevitable to bring higher harmonic component to the system and the relative motion caused by inertia of the machines makes the working environment much complex and terrible for the HTS magnet. To investigate the electromagnetic characterization of the LSM equipped with a NI coil, this paper introduces the experimental results of two HTS magnet, which are wound with different methods to compare their feasibility in LSM.

Experimental Set Up And Coil Parameters

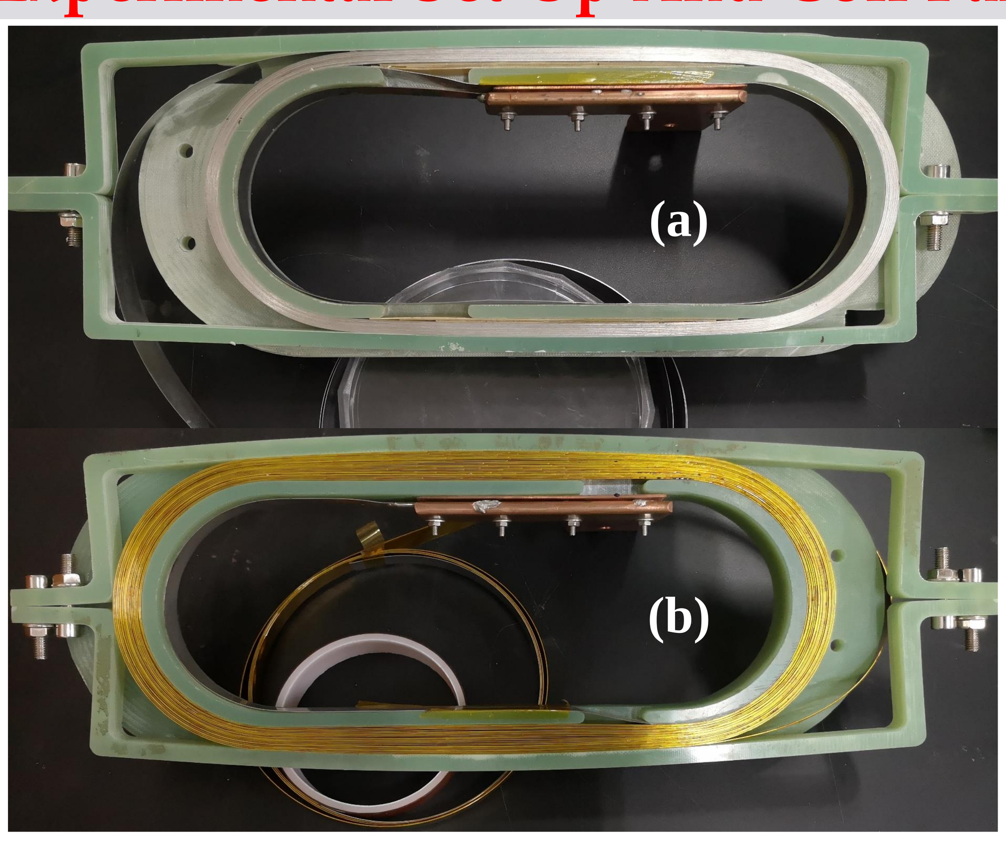

Fig. 1. Illustration of the racetrack coils: (a) NI coil; (b) INS coil.

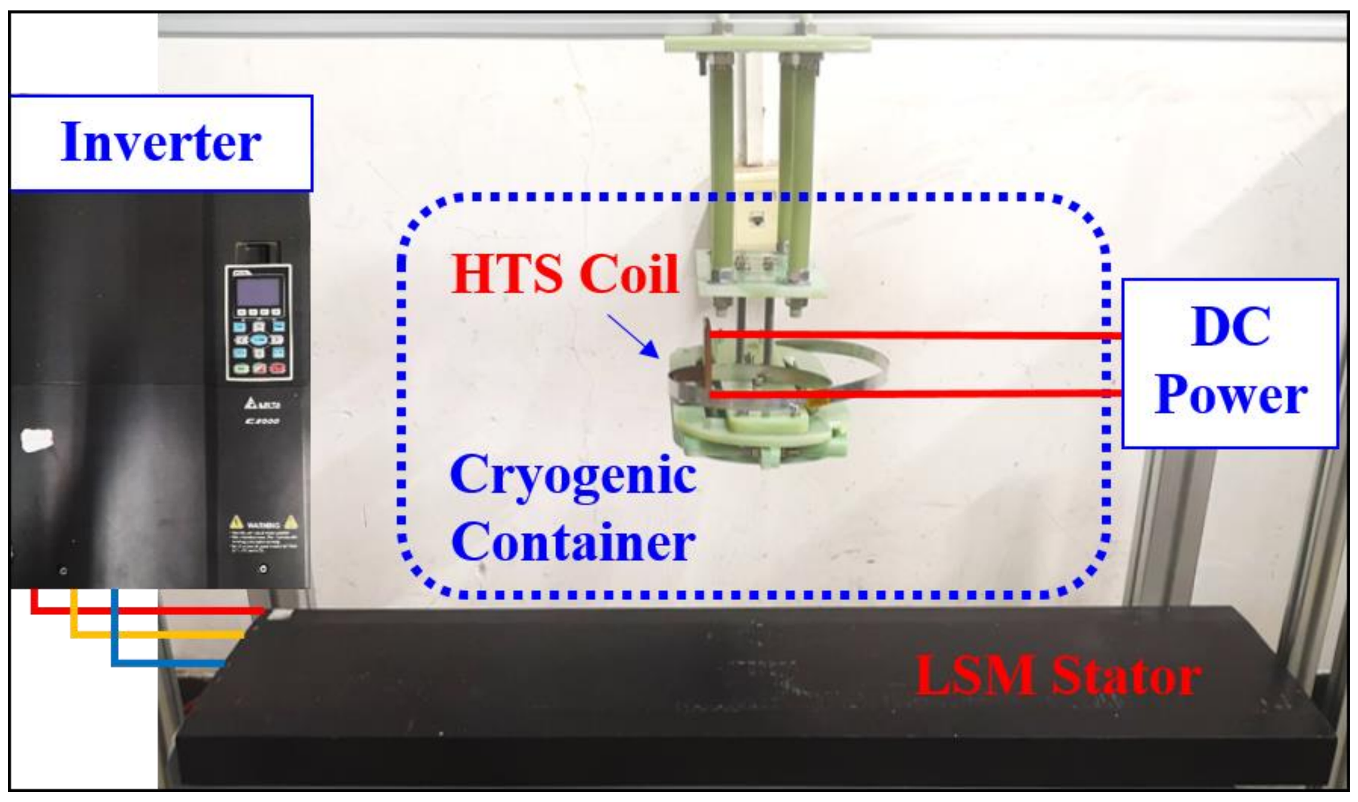

Fig. 2. Experimental scenario of the test system. (The stator controlled by a three-phase inverter; The HTS coils are charged by a DC power supply.)

Parameters	Values	
	NI coil	INS coil
Number of turns	20	
Height of the coil	16 mm	
Length of the straight part	160 mm	
Inner diameter of curve	105 mm	
Outer diameter of curve	116 mm	127 mm
Critical current (77 K)	188.5 A	211 A
Inductance	182 μH	179 μH
Coil constant	162 mT/A	156 mT/A

Table. I. Parameters of HTS racetrack coils.

Results - Charging Performance

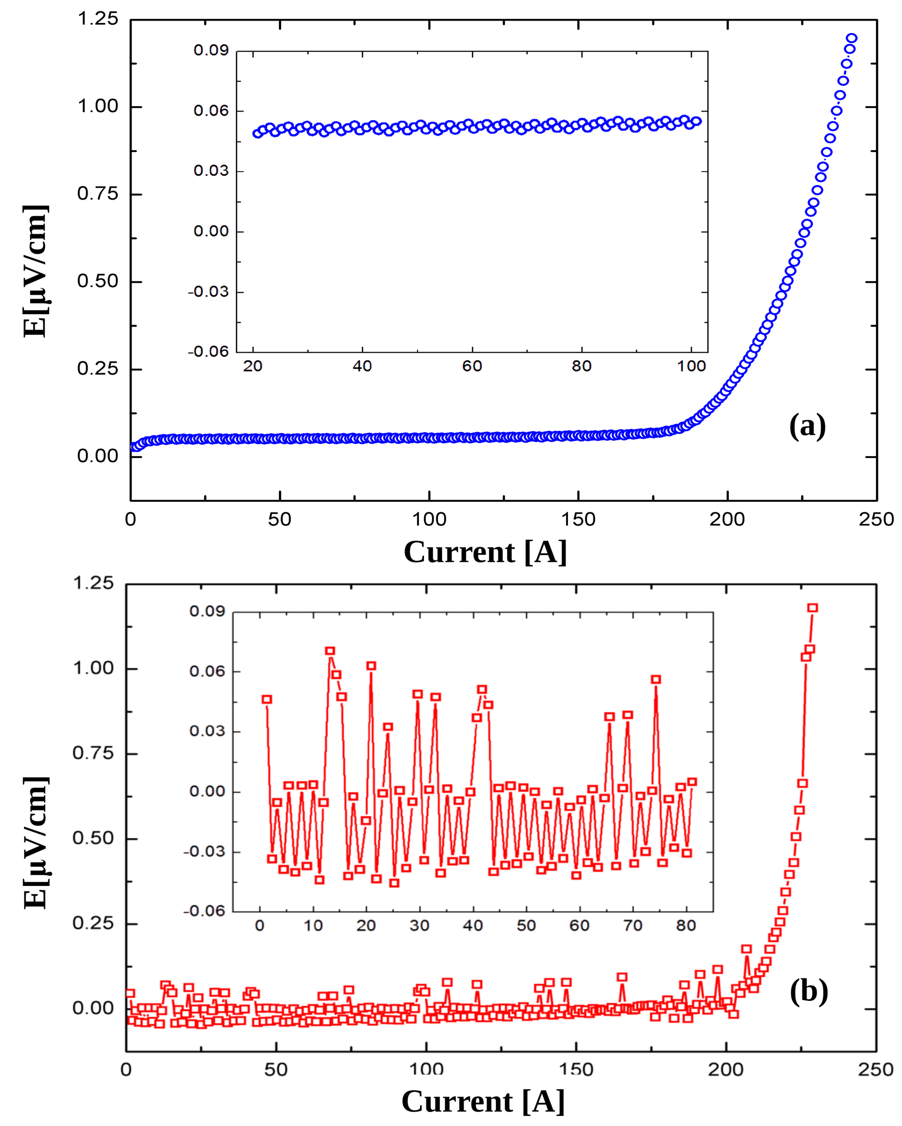

Fig. 3. V-I curve of (a) NI coil and (b) INS coil @77 K.

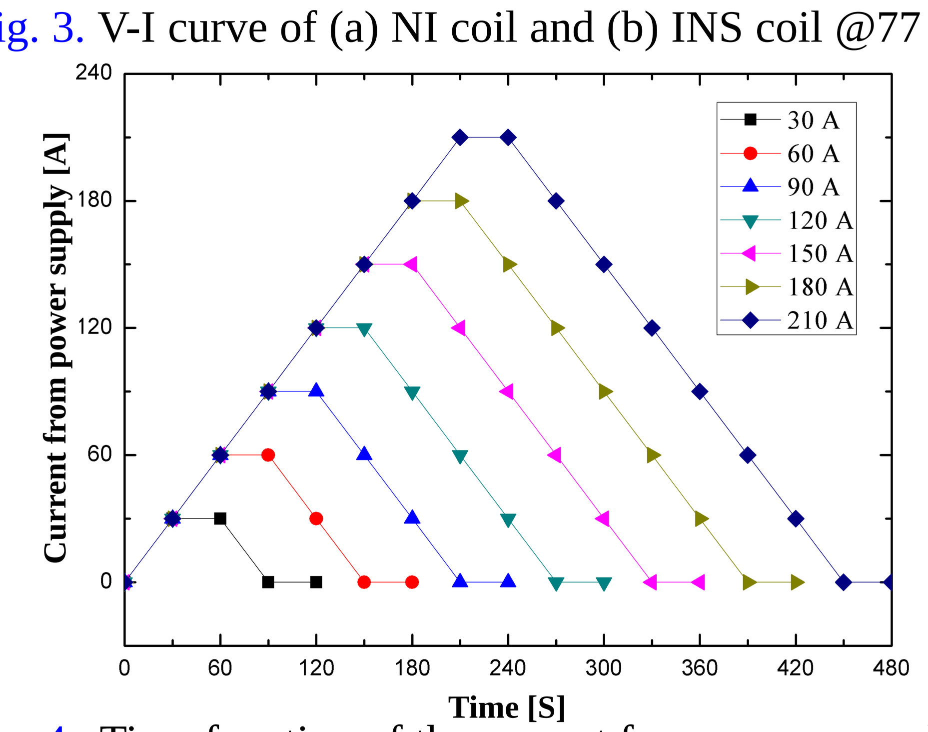

Fig. 4. Time function of the current from power supply.

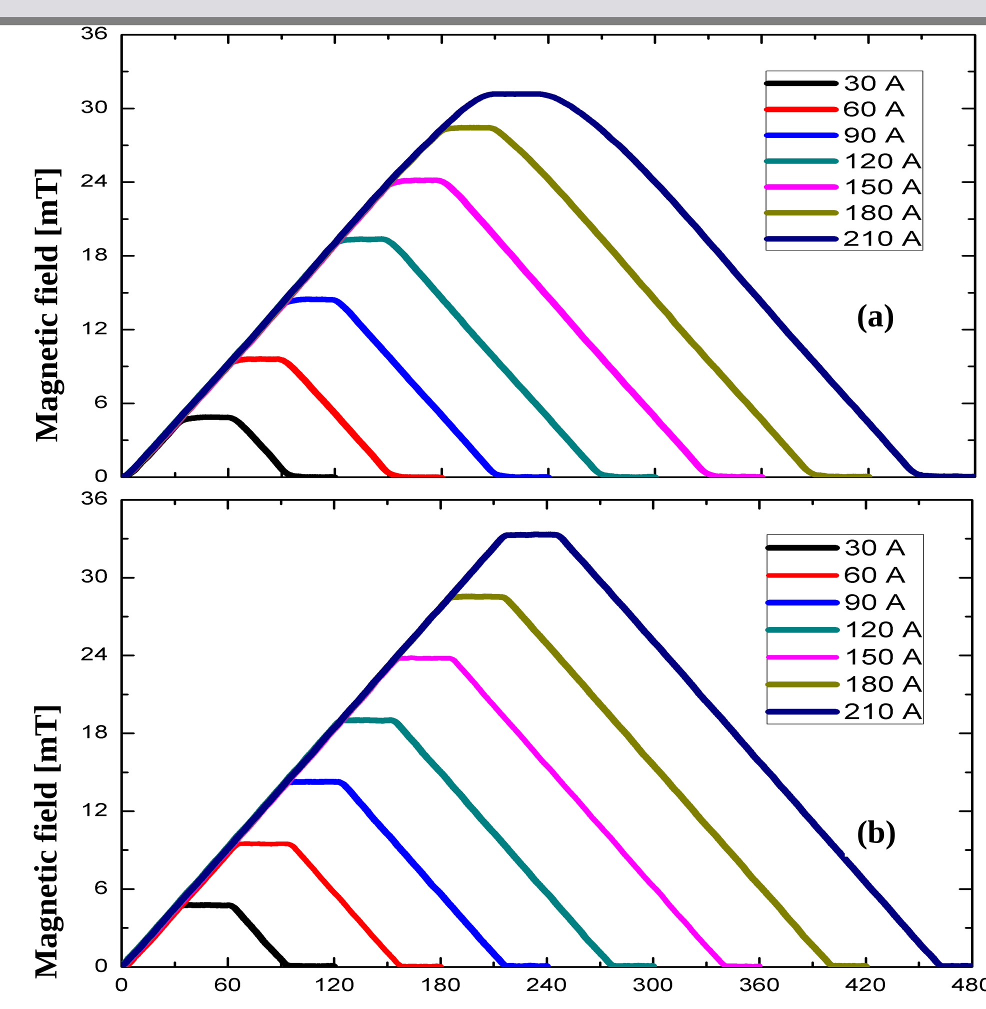

Fig. 5. Experimental results of the center field obtained from the NI coil (a) and INS coil (b) in charge and discharge test.

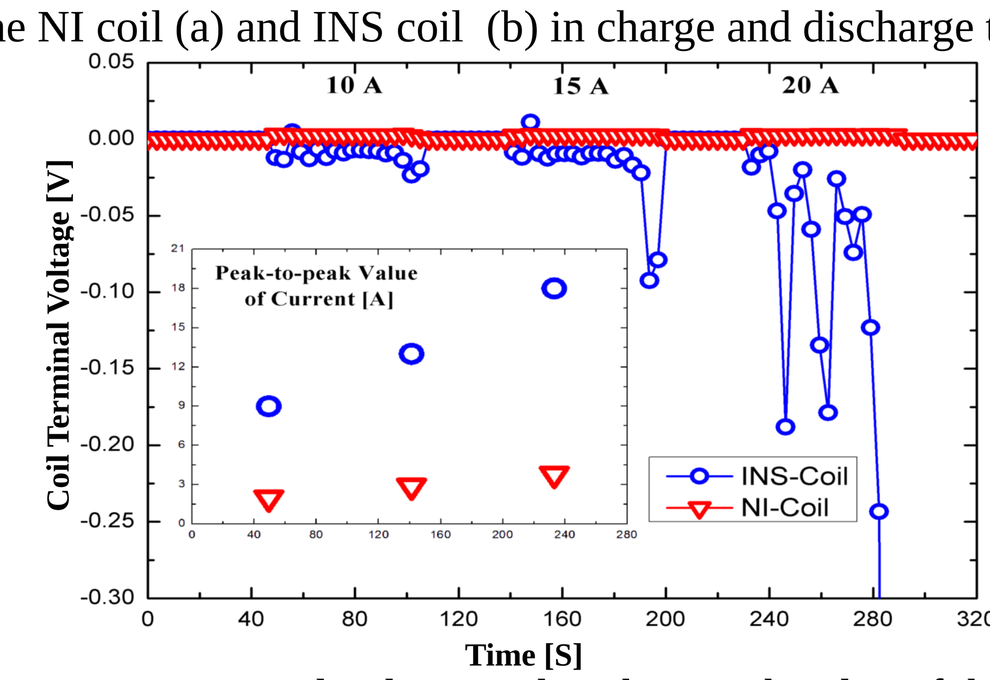

Fig. 6. Terminal voltage and peak to peak value of the current of the coils exposed to the external field from the stator with the ac current of 10 A, 15 A and 20 A @ 30 Hz.

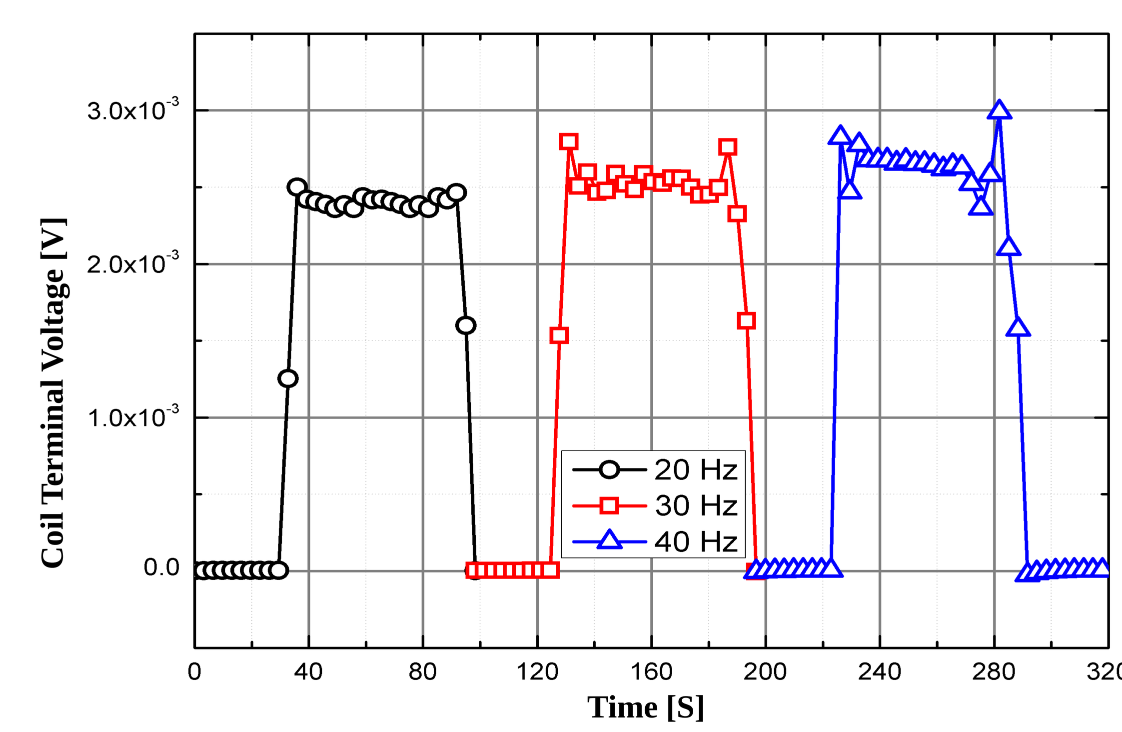

Fig. 7. Terminal voltage of the NI coil when exposed to the external field from the stator with the ac current of 20 Hz, 30 Hz and 40 Hz @ 20 A.

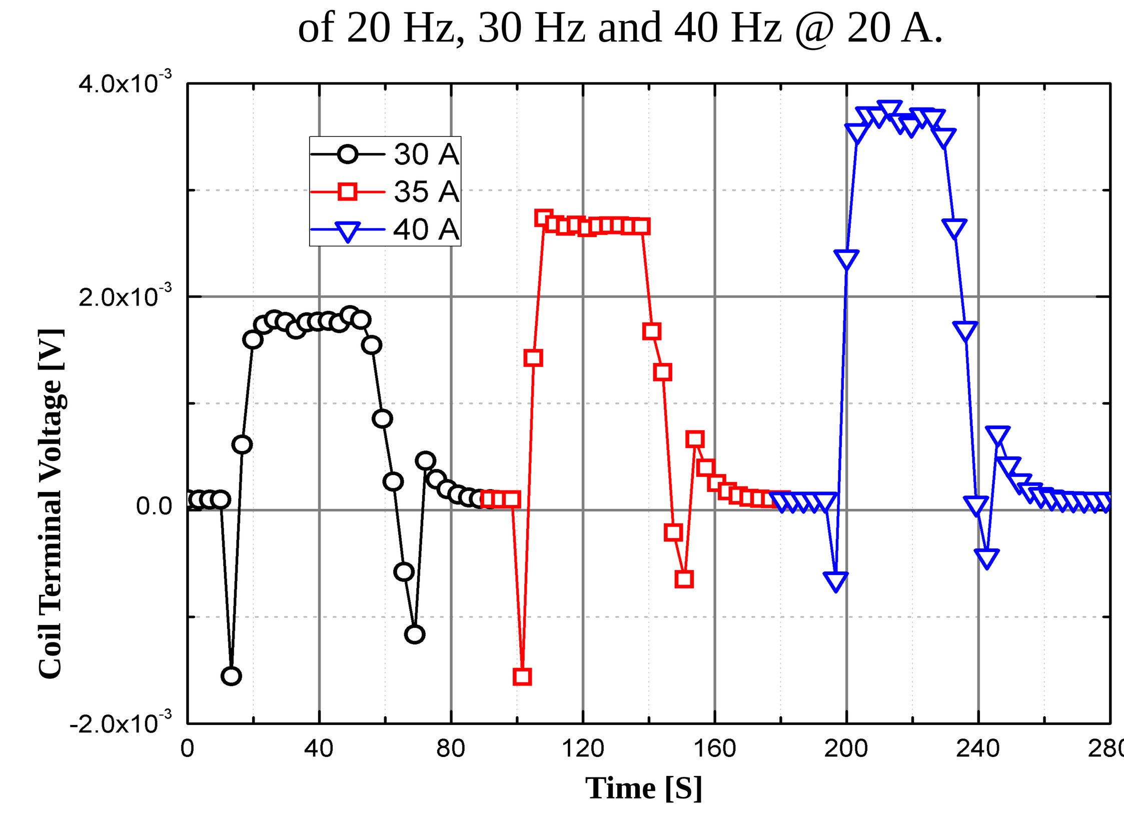

Fig. 8. Terminal voltage of the NI coil with its operation current of 188 A when exposed to the external field from the stator with the ac current of 30 A, 35 A and 40 A @ 30 Hz.

Conclusion

1) Compared to INS coil, the terminal voltage of NI coil is stable during the charging process and rises up slowly when it reaches the critical current because the charging current in the NI coil could have a redistribution due to turn to turn contact when local heat occurred, which proves that the electrical stability of NI coil is better than the INS coil;
2) The center field of NI coil would be saturated when it is charged over the critical current because the excess current could bypass through radial directions and thus the NI coil would not burn out in excessive situation due to its multiple current paths;
3) The stability of the NI coil is better than INS coil when exposed to the travelling magnetic fields both in normal and excessive conditions because the local quench in NI coil would recover quickly if the current bypassed it in radial direction, which demonstrated that the NI coil has better feasibility to work as the field magnet of a LSM.

Acknowledgement

This work was supported in part by National Natural Science Foun-dation of China under Grants 51722706, in part by the Open Research Fund of Key Laboratory of Space Utilization, Chinese Academy of Sci-ences(No. LSU-KFJJ-2019-05) and in part by the Key Laboratory of Space Utilization, Technology and Engineering Center for space Utiliza-tion, Chinese Academy of Sience. 100094, Beijing, China. *(Corresponding author: Guangtong Ma).*