Synchronous-Hysteresis Superconducting Machine with Stacks of Second Generation Tapes

F. J. M. Dias [1, 2], G.G. Sotelo[3], F. S. Costa [1], E. F. Rodriguez [1], A. Polasek[2], R. de Andrade Jr. [1]

1–Federal University of Rio de Janeiro (UFRJ), RJ (Brazil)

2–Electrical Energy Research Center (CEPEL), RJ (Brazil)

3–Fluminense Federal University (UFF), RJ (Brazil)

Abstract

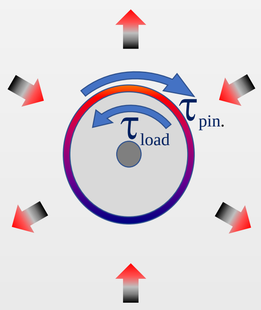
Superconducting Electric Machines (SEM) have some advantages compared to machines with conventional conductors, such as higher power density, weight reduction, increased efficiency, and higher overload capacity. Those properties make SEM ideal for several applications where a lighter and smaller machine is necessary. Generally, SEM are constructed using high temperature superconductor (HTS) bulks with trapped field or with superconducting tapes arranged as coils. Some works have been proposed to replace the HTS bulk by stacks of second generation (2G) HTS tapes to trap the magnetic field. Electric machines using trapped field in stacks of 2G tapes were not deeply investigated in the literature. In this context, the purpose of the present work is the studying of a SEM topology constructed with 2G tape stacks spirally arranged in the rotor. A small scale SEM prototype was constructed and tested @ 77 K in a laboratory bench. The constructed SEM can operate in the synchronous or hysteresis regimes, depending on the load torque. Results as quasi-static torque, torque at locked rotor and toque vs. speed are presented. These results can help us to project the next generation of SEM.

1. Superconducting Motor

A - Operating Principle

The superconductor magnetizes (partially or fully) according to the rotating magnetic field.

Six poles 3 phases machine



$\tau_{load} < \tau_{pinning}$

Synchronous machine (no losses in steady state)

- The resistant torque is smaller than that allowed by the electromagnetic forces and the pinning of the magnetic flux;
- The rotor moves in the synchronous speed;

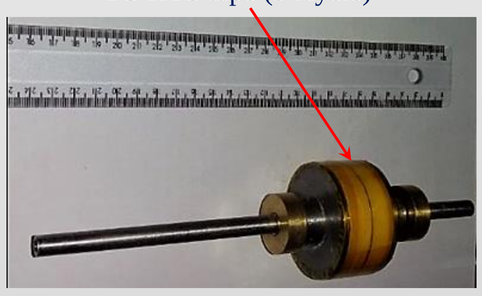
$\tau_{load} > \tau_{pinning}$

Hysteresis machine (Losses)

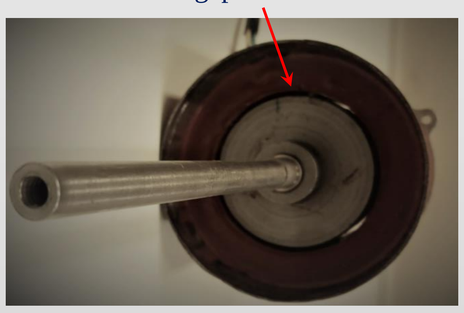
- The resistant torque is larger than that allowed by pinning of the flux and the electromagnetic forces;
- The rotor moves slower than the synchronous speed (there is a slip);

B - Prototype

2G HTS tape (9 layers)



gap = 2 mm

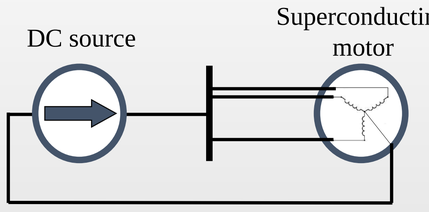


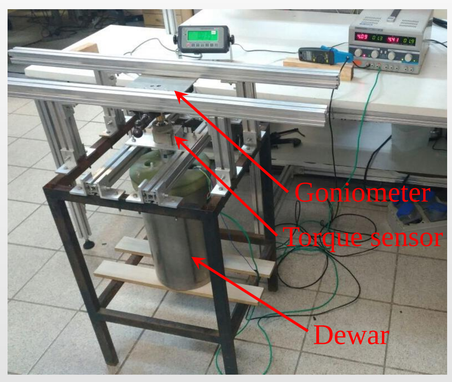
Dewar

Stator

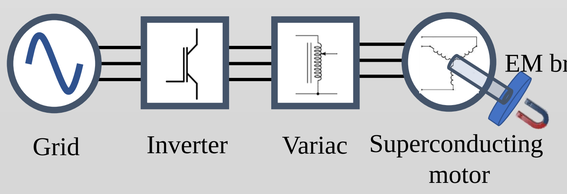
2. Experimental Setup

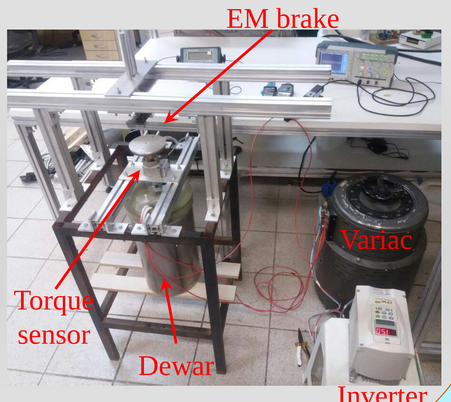
A - Quasi-Static measurements





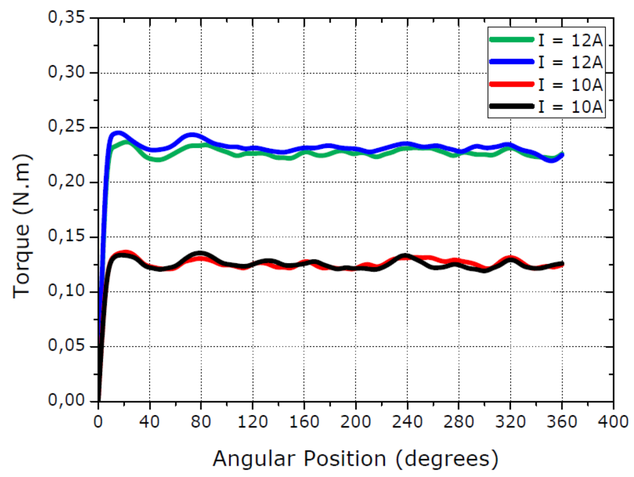
B - Dynamic and locked rotor tests



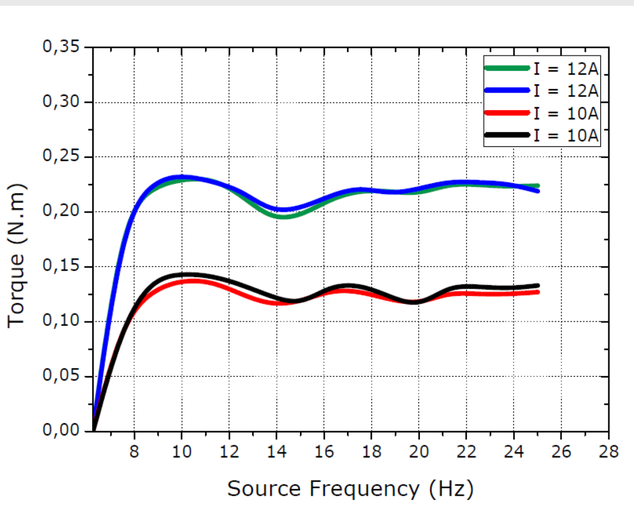


3. Results

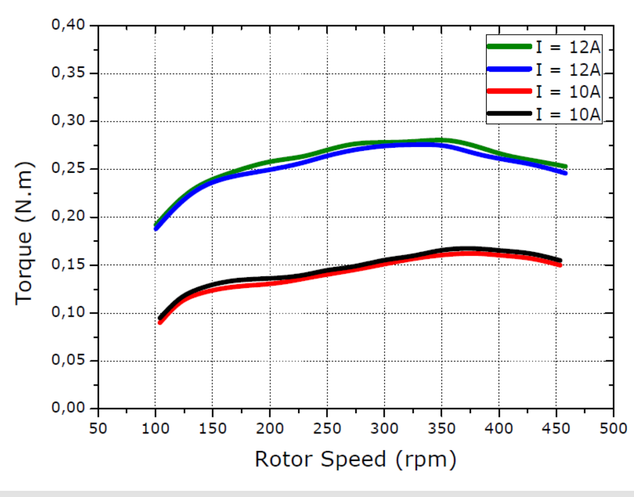
A - Quasi-static measurements



B - Locked rotor measurements



C - Dynamic measurements



4. Conclusions

This work presented the initial tests in a superconducting motor prototype constructed with 2G HTS tape stacks assembled in the rotor. The motor operates by the principle of trapped magnetic flux in 2G HTS tape stack. The synchronous and hysteresis (asynchronous) modes were observed during the experiments.

This kind of motor was not studied deeply in the literature and its basic behavior could be observed here. Promising results have been obtained for the modelling of this machine in the future works, which will help the authors in the further development of this concept.

5. Acknowledgments

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