ACRONYM : HPEM

Title: Development of key technology components for High Performance Electric Motors

State of the art – Background

The aim of the HPEM project is the study, design and construction of ten motor and sensor prototype parts for particular actuators involving high performance specifications in order to suppress the whole hydraulic system in rotorcrafts.

In particular it is intended to implement all available technologies enabling permanent magnet motor construction ensuring high power density and sensor configuration providing safe and accurate operation under harsh operating conditions. To that respect alternative axial and circumferentail motor segmentations will be compared, Silicium Cobalt iron laminations will be examined and Halbach array rotor configurations wil be explored.

Objectives

The major project objectives include conception and construction of ten electromagnetic actuators offering high power density, being able to withsatnd harsh environmental operating conditions and providing fault tolerance capability.

Methodologically, it is intended to implement electromagnetic actuator design optimization methodologies and validate the results by means of prototypes tested under under normal and fault conditions.

Description of work

In a first phase the preliminary design of the actuators has been performed including the selection of appropriate materials, configurations and technologies enabling to meet the desirable requirements. During this phase particular Silicium Cobalt iron laminations have been selected for the magnetic circuits providing high saturation magnetization and reduced losses. Furthermore two alternative motor configurations, involving axial and circumferential segmentations respectively, have been compared by performing design sensitivities through electromagnetic modeling by 2D finite element techniques in order to obtain the optimal values of the key geometrical and operating parameters and then the calculated electromagnetic performance and thermal characteristics have been assessed. The optimized configuration selected is the circumferentially segmented one, mainly due to its better thermal characteristics.

In a second phase the critical design has been performed, by selecting adequate insulating materials enabling temperature withstand up to 200 ^{o}C, implementing mica based components, windings composed of specially enamelled with aromatic Polyimide round copper wires, mica reinforced Nomex slot insulations and Samarium Cobalt alloy permanent magnets. Moreover, an appropriate resolver technology has been proposed presenting robust design and the increased thermal endurance for the the rotor speed and position sensing, which has demonstrated satisfactory performance under all the considered operating conditions for this application.

Finally the ten constructed motors have been extensively tested and after assessing their compliance with all characteristics of the defined operating conditions they have been delivered. Furthermore, in order to overcome some problems encountered after the mechanical assembly concerning the machine-converter coupling appropriate fitting and the harness of the mechanism driven by the delivered machines due to dynamic loading characteristics, specific corrective actions have been proposed.

Results

a) Timeline & main milestones

The preliminary design phase realised during the first year of the project has been finalized according to schedule.

However, during the critical design phase realised the second year of the project , a number of construction difficulties had to be overcome. In particular, at the validation stage of the constructed parts of the prototypes, appropriate adaptations and reconstructions have been performed due to difficulties encountered both on procurement procedures and on the implementation of newly defined technologies, involving rotor parts with Halbach array reconstruction as well as copper density modificaton in slots of stator parts. These difficulties have been overcome by an extension of six months of the project duration.

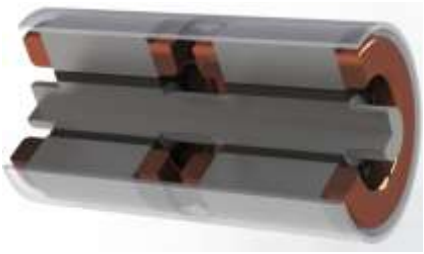
b) Environmental benefits

HPEM project particularly contributes to a sustainable development of the aeronautic industry. The new actuators will permit reduction of rotorcraft weight and power for control systems, and consequently reduction of fuel consumption. Moreover the elimination of hydraulic pipes aerospace applications with toxic hydraulic fluids will permit to ensure a better environmental quality of air travels and will prevent environment from toxic effluents.

c) Maturity of works performed

The applicability of the proposed actuators is an indispensable prerequisite to ensure that the proposed research and developments will be driven properly. It consists in a continuous identification, monitoring and qualification at the construction stage of the proposed technologies. The experience of project members on such constructions as well as the implemented firms in respective constructions as well as the configurations proposed ar in line with the basic directions generally admissible in all electric aircraft activities.

Picture, Illustration



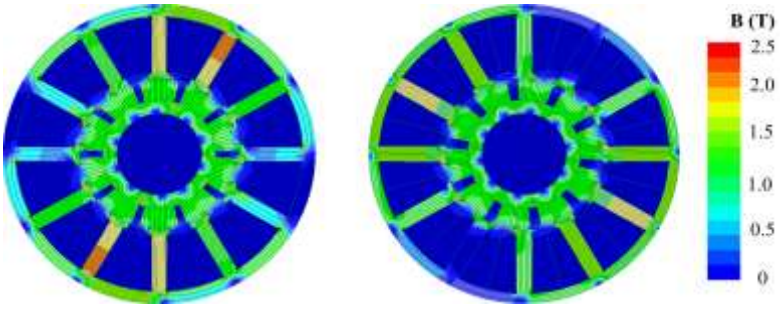
Axial Segmentation

SL FSCW topology

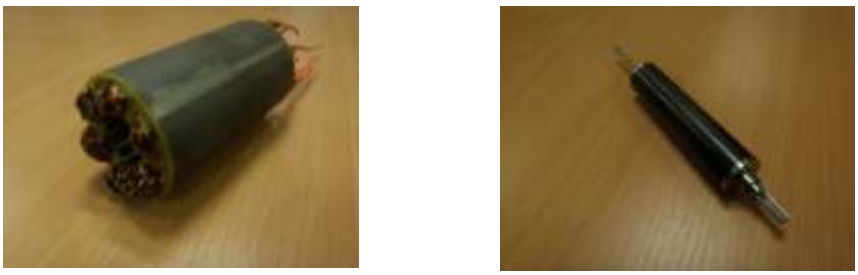
Circumferential Segmentation

DL FSCW topology

3D actuator configurations studied.



Respective magnetic field distributions



Constructed motor stator and rotor parts

Project Summary

Acronym : **HPEM**

Name of proposal: **Development of key technology components for High Performance Electric Motors**

Technical domain: **SGO-02-020**

Involved ITD

Grant Agreement: **271850 HPEM**

Instrument: **Clean Sky JU**

Total Cost: **249,400€**

Clean Sky contribution: **187,050€**

Call: **SP1-JTI-CS-2010-03**

Starting date: **1/12/2013**

Ending date: **30/11/2014 (extended 31/5/2015)**

Duration: **30 months (24 extended +6 months)**

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