Rare Earth Free e-Drives Featuring Low Cost Manufacturing

ReFreeDrive

Collaborative Project
Grant Agreement Number 770143

Start date of the project: 1st October 2017, Duration: 36 months

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 770143

Deliverable no.: D 4.4

Title of the deliverable: SynRel Full Design Track1 / Track 2

Contractual Date of Delivery:	**June 30th 2019**
Actual Date of Delivery:	**25 July 2019**
Lead contractor for this deliverable:	**UAQ**
Author(s):	**Marco Villani, Giuseppe Fabri, Andrea Credo**
Participants(s):	**UAQ**
Nature:	**Confidential**
Version:	**2.3**

Abbreviations

FE: Finite Element

KPI: Key Performance Indicator

PM: Permanent Magnet

PURE-SYNREL: Pure Synchronous Reluctance

WP: Work Package

EXECUTIVE SUMMARY

This document presents the final design of the Pure Synchronous Reluctance Motor (PURE-SYNREL), 200 and 75 kW: the main challenge was to design a high torque density motor without permanent magnets (PM) according to the external dimensions and the maximum speed of the motor, coherently with the Key Performance Indicators (KPIs) defined in Work Package WP2 and listed in Table ES.1. The Peak Power density and the Peak Torque density have been calculated with reference to the active volume considering wound stack length (without housing). The reference full-electric cars are: the Renault Fluent (for the 75 kW) and the Tesla Model S (for the 200 kW).

Table ES.1: KPIs for Pure SynRel Motors

Parameter	Unit	75 kW			200 kW		
		Reference Renault Fluence	RFD Goals	Achiev.	Reference Tesla Model S	RFD Goals	Achiev.
Specific Peak Power	kW/kg	1.94	> 2.52	4.04	3.3	> 4.3	5.3
Peak Power Density	kW/lit	8.75	> 8.75	13.1	19.7	>19.7	20.8
Specific Peak Torque	Nm /kg	6.3	> 8.2	8.23	6.32	> 8.2	8.4
Peak Torque Density	Nm/lit	28.2	> 28.2	26.6	37.7	>37.7	32.6
Maximum speed	krpm	12	12	12	14.5	15 ÷ 18	18
Peak efficiency	%	95	> 97	95	92	> 96	96
Active parts weight	kg	36	< 30	22	68	< 47	46
Motor dimensions Length	mm		< 310	180	225	< 310	310
Motor dimensions Outer Diam.	mm		< 250	220	254	< 250	220

KPIs consider the active parts only : stator and rotor lamination, copper wires and slot insulation.

The avenues indicated above have required a complex optimization process, by a multiphysics design approach, for matching the desired motor performances whilst respecting the target components cost.

The final design presents a rotor with “fluid shaped” flux barriers with multiple ribs in different positions with respect to the flux barriers. This geometry is quite unusual compared to those typically reported in literature and has allowed improving the motor performance: this solution has been tested by Finite Element (FE) analyses in order to verify the mechanical strength of the rotor core at high speed.

Therefore, the proposed designs have also an integrated cooling solution and the thermal behavior of the motor has also been verified considering the water jacket designed and proposed by Mavel partner in RefreeDrive consortium.

The lower power machine (75 kW) has been scaled from the 200 kW design by only changing the stator winding and stack length. Performances are reported in Figure ES.1 and Figure ES.2 (here reported for dissemination).

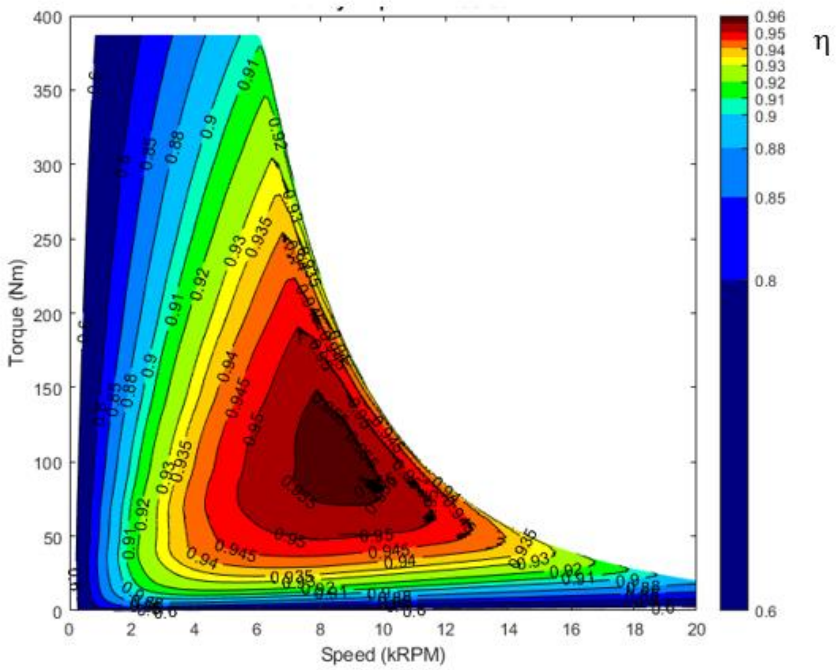

Figure ES.1: 200 kW Pure SynRel Motor – Efficiency map

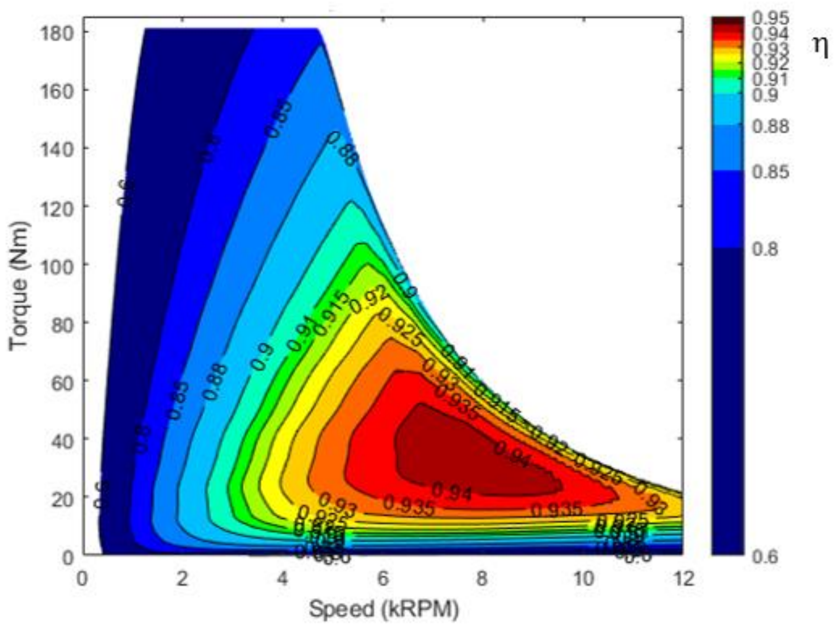

Figure ES.2. 75 kW Pure SynRel Motor – Efficiency map

In order to manufacture the PURE-SYNREL motors, within WP6, executive drawings have been made for the construction of the stator and rotor cores and the winding insertion.

In Section 1 are described the main choices of the motors to be prototyped.
Section 2 and 3 give an overview of the 200 and 75 kW motors.

The impact of the tasks 4.3.1 described in D4.4 is:

- Full manufacturing drawings of the PURE-SYNREL motors: 75kW and 200kW;

- Final performance validation of the designs;

- Increased know-how of the partner involved in the design and validation of PURE-SYNREL.

- Increased confidence of the partners on the behaviour of the target electric motors.

The recognized barriers and risks do not affected the development of the project strategy for Task 4.3.1.

According to the consortium agreement each partner involved can use their own work and related results included in this deliverable for dissemination.

In D4.4 there have been no deviations in content or time from the deliverable objectives set out in the ReFreeDrive Grant Agreement.