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# Taking into Account Manufacturing Faults in PMSM for Diagnosis Purposes

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**Abstract**— This paper deals with some problems related to the use of fractional slot winding configurations in recent PM motors designs. The main idea is to take into account specific characteristics such as parasitic air-gaps which are leading to unexpected behaviors. Depending on the situation this behaviors can be mistaken electrical or mechanical faults. The aim is to develop improved models of compact actuators avoiding false alarm issues in diagnosis methods.

## I. GENERAL ISSUES OF RECENT PMSM DESIGN

Recently, Permanent Magnet Synchronous Motors (PMSM) design has been strongly improved answering to automotive industry or aircraft transportation requirements. Fractional slot winding configurations are now widely used creating by the way compact actuators with high torque/mass ratios mainly by reducing coils end configuration [1]. Some assembly techniques of iron lamination, as shown on Fig. 1, have been used to make possible the automatic winding of such actuators. The major drawbacks of these assembly techniques are eddy current losses, radial force unbalances and construction fault introducing parasitic air-gaps.

## II. MODELING OF SOME MANUFACTURING FAULTS

Generally fractional slot PM motors can be built using the assembly process depicted on Fig.1-a or Fig.1.b. As an illustration, a 18 slots 16 magnets PM motor is considered with a parasitic air-gap between one tooth and the stator's yoke such in Fig.1-c. Its thickness is called  $e_p$  and it is assumed to be constant along the teeth top. Due to this parasitic air-gap, two main consequences can be observed. The first one concerns direct and quadrature fluxes which contain second order harmonics. This can evaluate by both Finite Element (FE) and Permeance Network (PN) models as shown on Fig.2 [2]. The second consequence concerns the apparition of a high level of cogging torque depending on the position and the thickness of the parasitic air-gap. The frequency of this torque matches with the 2<sup>nd</sup> harmonic of the supply frequency. Consequently to this construction faults, the motor behaves as a motor with an inter-turn fault even if its windings are healthy. Such situations should be confusing especially for on-line monitoring techniques of inter-turn faults.

## III. CONSEQUENCES REGARDING FAULT DETECTION

The presence of these inherent faults has a great influence on fault indicators used in monitoring techniques [3]-[5]. Indeed, neglecting these effects in the healthy model of the motor can lead to the non detection of short-circuit faults involving few turns and creating weak unbalance.

In the full paper, improved model which allows creating new indicators able to be relevant even for motors with parasitic air-gaps, will be presented.

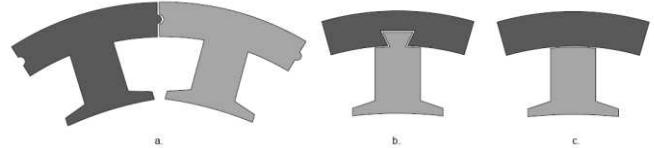


Fig. 1: Example of recent PMSM designs.

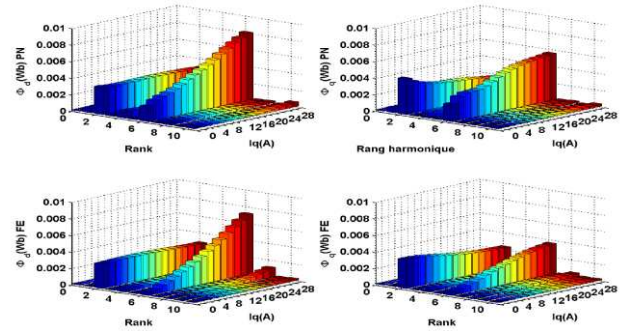


Fig. 2: Direct and quadrature fluxes harmonics with  $e_p = 0.2mm$  (fundamentals are removed)

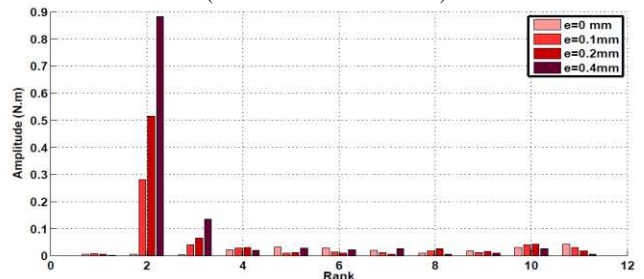


Fig. 3: Cogging torque spectrum in the studied cases.

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