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Design of Grid-Connected to Rotor Type Doubly-Fed Induction Generators for Wind Turbine System

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Design of Grid-Connected to Rotor Type Doubly-Fed Induction Generators for Wind Turbine System

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Abstract— Doubly-Fed Induction Generators (DFIGs) are widely used for modern wind turbines. Although the stator winding of DFIG is directly connected to a grid while a rotor winding is connected to converters, it has a large outer size because of the high current in the stator winding. This paper proposes a grid-connected to a rotor type DFIG where rotor winding is connected to the grid instead of stator winding. In order to verify the size reduction of the proposed type, a loading distribution method (LDM) is utilized. Then the characteristic analysis is performed using the equivalent circuit method (ECM). As a result, the total volume of the proposed type was decreased by about 10.73 %. In addition, the total core weight of the proposed type was also decreased from 24.5 kg to 21.9 kg.

I. INTRODUCTION

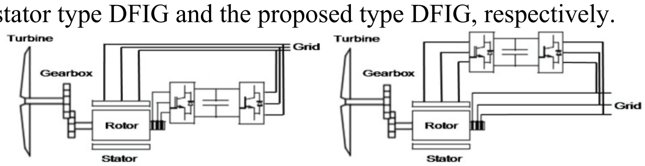
Doubly-Fed induction generators (DFIGs) have been widely used for wind turbine systems due to variable speed operation, small size and low cost of converter compare to squirrel cage induction generator. Although the stator winding of the DFIG is directly connected to the grid while a rotor winding is connected to back-to-back AC/DC/AC converters, it has large outer size because of the high current in the stator winding [1]. In order to improve this problem, research on the control of the current and power control of DFIGs has progressed. However, this research is not the solution to reduction of the high current of stator winding.

This paper proposes a grid-connected to a rotor type DFIG where rotor winding is connected to the grid instead of the stator winding. Otherwise, the stator winding of this proposed type is connected to converters. Although the conventional grid-connected to the stator type DFIG cannot utilize core around rotating shaft as flux path, the proposed type can use rotor core sufficently. In addition, the stator size of the proposed type can be reduced because the current of the stator winding is decreased.

In order to verify the size reduction of the proposed type, loading distribution method (LDM) was utilized [2]. Then the characteristic analysis was performed by equivalent circuit method (ECM) [2].

II. DESIGN OF GRID-CONNECTED TO ROTOR TYPE DFIG

Fig. 1(a) and (b) shows conventional grid-connected to a stator type DFIG and the proposed type DFIG, respectively.



(a) A grid-connected to stator type (b) A grid-connected to rotor type
Fig. 1 Schematic diagram of DFIG

The conventional grid-connected to a stator type DFIG is designed as the outer diameter of the rotor after determination of the stator parameter. Therefore, the rotor size is unnecessarily larger and the rotor core cannot be sufficiently utilized.

However, outer diameter of the rotor in the proposed type is designed in advance, and then the stator parameters are determined as shown in Fig. 2. Therefore, the rotor core can be used as a flux path fully and the stator size can be reduced because the stator current is decreased.

Table 1 shows the design results by using LDM and ECM. As a result, the total volume of the proposed type was decreased from 3,183,672 mm^3 to 2,841,989 mm^3 meaning a 10.73 % reduction of DFIG size. In addition, the total core weight of the proposed type was also decreased from 24.5 kg to 21.9 kg. Although air-gap length of the proposed type is also decreased due to the reduction of ampere-turns per pole, it did not affect the manufacturing.

From these results, the proposed grid-connected to the rotor type DFIG showed the usefulness of reduction of size, weight and material cost for wind turbine system.

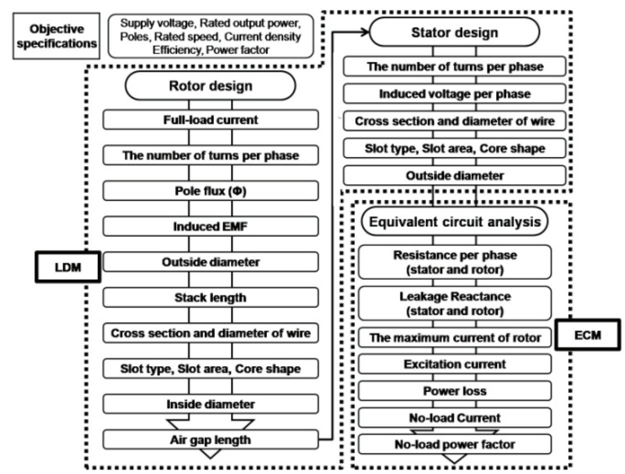


Fig. 2 Design process of grid-connected to rotor type DFIG

Table 1 Design results of DFIGs

Items			Unit	Grid-connected to stator type	Grid-connected to rotor type
Objective specifications		Rated output power	kW	3	
		Rated voltage	V	220	
		Number of Poles	-	4	
		Frequency	Hz	60	
LDM	Stator	Outer diameter	mm	189.4	186.8
		Inner diameter	mm	111.43	123.05
	Rotor	Outer diameter	mm	110.84	122.5
		Inner diameter	mm	28	28
		Air-gap length	mm	0.294	0.274
		Stack length	mm	113	103.7
		Total volume	mm^3	3,183,672	2,841,989
		Total core weight	kg	24.5	21.9
ECM	Stator	Resistance per phase	Ω	0.666	0.011
		Leakage reactance	Ω	1.372	0.011
	Rotor	Resistance per phase	Ω	0.015	0.635
		Leakage reactance	Ω	0.028	1.49
	Current (Grid side)	Maximum load	A	46.11	49.31
		No load	A	3.24	3.02
	Power factor	Maximum load	-	0.879	0.893
		No load	-	0.179	0.184

III. REFERENCES

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