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INDIRECT FRQUENCY CONVERTER FOR THE SUPPLY OF THE ROTOR OF THE ASYNCHRONOUS MOTOR

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Abstract: This project deals with attributes of the electric drive with the double fed machine. In the working mode the stator's winding will be connected into power network and the rotor is supplied by the indirect frequency converter.

Keywords: doubly fed machine, doubly fed generator, indirect frequency converter, asynchronous motor with wound rotor

1 Introduction

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The using of doubly-fed machine with the cycloconverter have many advantageous for the very high value of performance (about hundreds MW) and for some special applications. In the other cases this drive is unattractive, because the cycloconverter is very complicated device. This is why for the using of doubly-fed machine in common applications is necessary to use indirect frequency converter. The indirect frequency converters with DC-voltage link are produced by a plenty of producers in the big series (it means, that the cost of this converters is relatively very small but the quality and credibility are very high - for example see [2]). The typical configuration of these converters is shown in fig.1. The control circuits was developed for using for control of asynchronous motor. For the other using (for example for supply of doubly-fed machine etc.) these circuits must been re-adjustment. The simplified control algorithms which can been used for the control of doubly-fed machine is shown for example in fig.10 or was been described in [5], in [13] or in [15].

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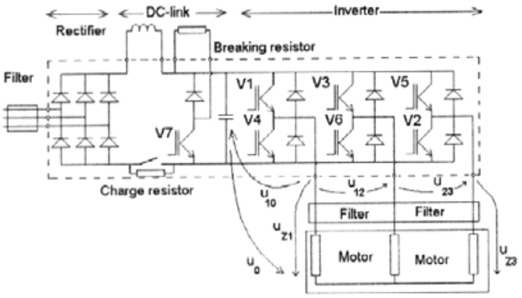

Fig.1. The typical configuration of the indirect frequency converters (with diode rectifier and voltage inverter with IGBT)

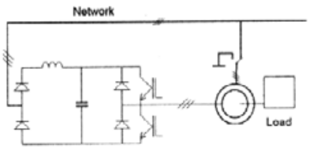

Fig.2. The simply using of typical frequency converter with doubly-fed machine

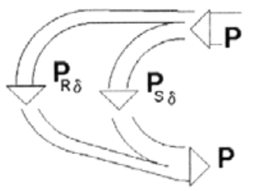

Fig.3. The schema of flow of performance in drive – Regime as a motor in super synchronous velocity

2 Using of the converter without recuperation

Let us to divide the using of frequency converter for the supply of doubly-fed machine into two cases (this division depend on the type of input rectifier, which is used in this frequency converter):

A) Special frequency converter with recuperation – for example converter with four-quadrant rectifier or with recuperative unit (see next chapter 3).

B) Standard converter without possibility of recuperation of energy from converter to supply grid (for example with diode rectifier - see fig.1). This case will been described in this chapter:

We can approximately qualify (for example see [11]) the value of input performance $\mathbf{P_{S\delta}}$ into stator's winding (without losses etc.) using the synchronous velocity $\boldsymbol{\omega_S}$ (for 2-poles machine), main inductance $\mathbf{L_H}$ (inductance between stator's and rotor's windings), torque $\mathbf{M_T}$ (for 2-poles machine) and actual values of currents:

$$P_{S\delta} = k_P \cdot \omega_S \cdot (i_{SY} \cdot L_H \cdot i_{RX} - i_{SX} \cdot L_H \cdot i_{RY}) =$$
$$= k_P \cdot \omega_S \cdot L_H \cdot (i_{SY} \cdot i_{RX} - i_{SX} \cdot i_{RY}) = \omega_S \cdot M_T \qquad (2.1)$$

Input performance $\mathbf{P_{R\delta}}$ into rotor's winding (so called "slip performance") have approximately (without losses etc.) this value (in this formula values ω means the velocity for the rotor for 2-poles machine):

$$P_{R\delta} = k_P \cdot (\omega_S - \omega) \cdot L_H \cdot (i_{RY} \cdot i_{SX} - i_{RX} \cdot i_{SY}) = (\omega - \omega_S) \cdot M_T \qquad (2.2)$$

This equitation means that, when as converter is used the converter without the possibility of recuperation of energy from converter to supply grid, the subsynchronous velocity and positive torque $\mathbf{M_T}$ (regime as a motor) is improper (because slip performance $\mathbf{P_{R\delta}}$ means only the losses on the breaking resistor in converter – see fig.1). This is why the using of this type of drive is complicated to use as a motor (for example it brings some problems of start-up – see for example [14]). The using as a motor brings an effect for drives when the full torque is need only in high velocity (for this regime see fig. 3) - for example fan or centrifugal pump (for the low velocity the doubly-fed machine must be connect as a asynchronous motor – for example see switch in fig. 2).

One possibility of using of this drive is application as a doubly-fed generator (DFG) for wind power system (see fig.4 or [10]) The equitation (2.2) mean that the working range of velocity must be subsynchronous (see fig.5 –

there are all performances are negative in consumer's system). For the supersynchronous value of velocity is necessarily to use converter with the possibility of recuperation energy – for example see next chapter 3.

The most winning application can be generator with combustion engine - for example the using for diesel-electric locomotives with asynchronous motors. This solution bring some disadvantages (one generator for all motors means, that all axle have the same value of torque) - but this disadvantage in some applications are not importance (for comparing see [3] - there is described similar situation, when all motors are supplied by one inverter). This application yield another problems and this is why is necessarily to compare this solution with the other variants of moderns drives (see for example [6] or [1]). The most importance advantage of this application is the fact, that the size of used converter can be less then performance of combustion engine (for full range from zero to maximal value of velocity of axles – it means the change of synchronous velocity). In fig.6 is shown the limitation of maximal performance of whole drive depend of the maximal slip performance $\mathbf{P_{Rmax}}$ (for the same value of performance we must size of converter) in some regimes.

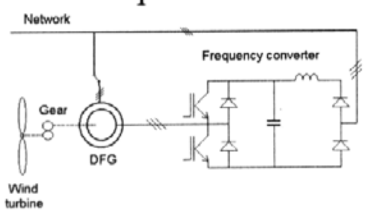

Fig.4. The simply using of typical frequency converter for wind power system

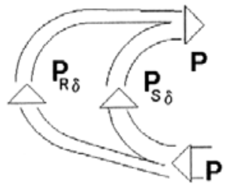

Fig.5. Regime as a generator in sub synchronous velocity

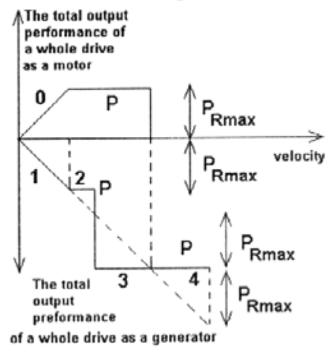

Fig.6.The total performance P of the drive in regimes :
0 (as an asynchronous motor for start-up of engine),
1 and 2 (as an asynchronous generator for low velocity)
3 and 4 (as a DFG for high velocity)

3 Using of the converter with recuperation

The converter can be realized either as a direct converter (for high performance see [11] or [4]) or as an indirect converter with current inverter (see [7]). For the common applications are used indirect converter with voltage inverter (see fig.1). For the supply of this inverter must be using either classical four-quadrant thyristor rectifier (see fig. 7) or standard diode rectifier with regenerative unit for example as an external appendix (see fig.8) or the more progressive solution pulse rectifier (see fig. 9).

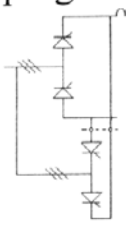

Fig.7. The classical reversibly rectifier

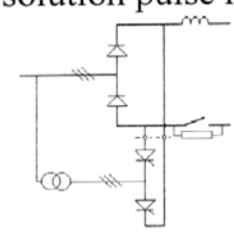

Fig.8. The diode rectifier with regenerative unit

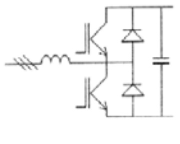

Fig.9. The pulse rectifier with IGBT

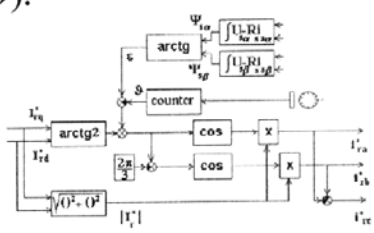

Fig.10. The pulse rectifier with IGBT

The using of these converters bring a new advantages, because this drive can operate arbitrary with positive or negative torque in subsynchronous or in supersynchronous velocity (without losses in breaking resistor).

4 The Conclusion

In this paper was been described some practical examples of using of drive consist of doubly-fed machine and indirect frequency converter. This paper considered as a converter both the standard frequency converter (consist of the diode rectifier and of the voltage inverter - see fig.1) without the possibility of recuperation energy from converter to supply grid (see chapter 2) and other configurations of the converter. The using of standard frequency converter (without the possibility of recuperation) bring some disadvantageous (for example doubly fed generator can been used as a motor only in subsynchronous velocity etc.). This disadvantageous reduced the possibilities of using only in some applications (some of this was been described in chapter 2).

Some configurations of the converter with the possibility of recuperation energy from converter to supply grid were been shown in chapter 3.

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