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A Performance Analysis of a Hydrogenerator In The Case of Field Short-Circuit Using FEM

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Abstract. The maintenance of synchronous generators is very significant for the energy production. Being aware of the performance of a synchronous machine during different kinds of faults, such as phase to phase, phase to ground or field short-circuits, could provide useful information about their protection. A short-circuit in the field excitation is not a common fault, but it is severe enough to create high oscillations to both electrical and mechanical magnitudes (field, stator and damper currents, rotor shaft torque, load angle etc). Such kind of faults is difficult to examine and provide experimental results because of the kinds of generator used for energy production. The size of these machines, either hydrogenerator or turbogenerator, is enormous for experimental laboratory studies. Another important issue that arises is the difficulties in the accurate calculation of the damper currents during transient operation. The Finite Element Method analysis gives solution to this kind of problems, as it can calculate as well the damper, stator and field currents as the electromagnetic field distribution inside the air gap.

Key words

Damper currents, field excitation short-circuit, Finite Element Method (FEM), hydrogenerator, transient behaviour

1. Introduction

The last decades the use of renewable sources for energy production is rising rapidly. Despite the increase of the renewable energy systems, the power produced by hydrogenerators remains an important source of energy production. The maintenance of these machines is very significant, as a disconnection from the grid due to electrical faults could create serious problems to the power production. Being aware of the machine's performance during a field short-circuit, we can achieve useful information about the electromagnetic torque oscillation, the damper and stator currents and the affection of these oscillations to the field current.

In this paper the effects of a fault in the excitation supply of a salient pole synchronous generator is investigated. We consider that this fault happens when the machine operates at full load and is connected to the 50 Hz grid. In the literature several types of fault have been studied [1]-[4], but not this fault and under this certain operation. During this transient operation are all the currents, the electromagnetic torque, the load angle and the radial magnetic flux component inside the air-gap of the generator have been investigated.

The advantage of the finite element analysis, comparing to other methods, is that some of the abovementioned magnitudes can be calculated and observed more precisely and easily through the steady-state and transient operation. The damper currents of the machine exist at both steady-state and transient operation due to the saliency of the machine [5]. These currents could cause serious damage to the insulation of the damper cage, as they get high values during the fault. These kinds of currents are produced because of the fault which causes the electromagnetic torque oscillations. These oscillations have serious affection on the load and applied torque of the rotor shaft and lead the machine to pole slip.

During the simulation the mechanical torque of the rotor shaft is controlled by a PI-Controller in order to obtain more accurate and precise results. Although the machine speed is controlled to keep it equal to the synchronous one, a consideration about fixed constant speed leads to non-accurate results. This happens because by constant speed the machine can't lead to pole slip.

The study of the magnetic flux distribution during transient operation is very significant in the comprehension of the hydrogenerator electromagnetic behaviour. The finite element method provides the tool to analyze these magnitudes and examine their affection to the machine behaviour.

2. Modelling of the system

A. The PI-Controller

To obtain more accurate and realistic results of the simulated machine transient behaviour, a controller for the mechanical applied torque was inserted in the programme. Fig.1 presents the basic structure of the PI-Controller for the mechanical torque, when the machine is connected to the grid.

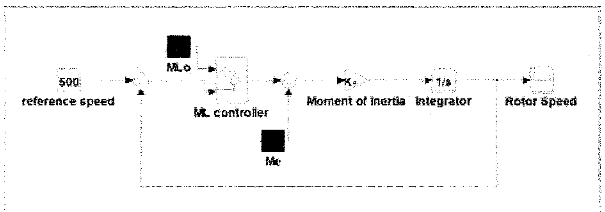

Fig. 1. The PI-Controller