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New applications of extruded solid dielectric cables

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Résumé

ABB a développé une nouvelle catégorie de générateurs, Powerformer™, capables de fournir du courant électrique directement à des niveaux transmission-tension. Cela a été réalisé en passant des traditionnels bobinages statoriques à conducteurs rectangulaires aux bobinages à conducteurs circulaires basés sur une technologie éprouvée de câbles à haute tension à diélectrique solide extrudé. Aujourd'hui, une seule unité peut remplacer le générateur conventionnel, les disjoncteurs de générateur, les bus d'alimentation de moyenne tension, les limiteurs de surtension du générateur et le transformateur élévateur de tension. Powerformer représente ainsi un concept totalement nouveau dans la technologie des centrales électriques. L'article examine quelques-unes des caractéristiques particulières des câbles utilisés.

Abstract

ABB has developed a new class of generators, Powerformer™, which are able to deliver electric power directly at transmission-voltage levels. This has been achieved by changing from traditional stator windings with rectangular conductors to windings with circular conductors based on proven high-voltage cable technology with solid extruded dielectric. Now, one single unit can replace the conventional generator, generator circuit breakers, medium voltage busbars, generator surge arresters, and the step-up transformer. Thus, Powerformer represents a totally new system concept in power plant technology. The paper discusses some of the special features of the cables used.

1 Introduction

To maximize the current loading in the conventional generator, the stator windings are made up of rectangular insulated conductor bars. To minimize the eddy current losses in the stator coils, the individual copper laminations constituting the conductor bars must be insulated and transposed along the winding according to an elaborate scheme[1-4]. The shape of these conductors results in an uneven electric field distribution with high electric field strengths at the corners. Also, in the end-winding region, intricate measures have to be taken to control the electric field so as to avoid partial discharges and corona. The design philosophy of the conventional generator has prevented the output voltage from exceeding about 30-35 kV. In contrast, the voltage for power transmission has reached levels of 800 kV and even higher. Apparently, a power plant based on a conventional generator very often requires a step-up transformer.

A completely new type of generator, Powerformer™, was recently presented by ABB [5,6]. It offers a direct connection to the power network without the need for a step-up transformer. Contrary to conventional generators, the windings of this new high-voltage generator has cylindrical conductors. As can be inferred from Maxwell equations, a cylindrical conductor yields an even electric field distribution. This is a prerequisite for all high-voltage apparatus. Basically, the stator winding of Powerformer is based on a technology originally developed for high-voltage power cables. Consequently, the output voltage of Powerformer is only limited by the state-of-the-art high-voltage cable technology.

The windings of Powerformer consist of insulated cables similar to conventional solid dielectric cables. However, the mechanical, the electrical, the magnetical, and the thermal environment surrounding the cable impose some new requirements not only on the cable itself but also on the design of the generator stator. This paper will discuss some of the special features of the cable system used in Powerformer.

2 The winding concept

Figure 1 illustrates the electric field around the conductor of the rectangular coil used in the conventional generator and the circular cable winding used in Powerformer, respectively. Today's insulation materials and production techniques offer reliable cables at operating gradients of the order of 10 kV/mm and even more. Such high electrical fields are not accepted for the conventional mica/epoxy based coil insulation. The cable itself consists of a conductor, an inner semiconductive layer, a solid dielectric and, finally, an outer semicondutive layer according to figure 2. In