FOURTH AUSTRALASIAN CONFERENCE
on
HYDRAULICS AND FLUID MECHANICS
at
Monash University, Melbourne, Australia
1971 November 29 to December 3

FLUID FLOW IN LARGE ELECTRICAL TURBOGENERATORS

by

A. Williams

SUMMARY

Problems of fluid flow arise in electrical machines from the necessity to remove the heat dissipated from electrical, magnetic, and mechanical losses within the components of the machines, whilst maintaining safe working temperatures of these components. The very rapid increase in the size of large turbogenerators (about twenty fold in twenty years) has been made possible by improved systems of cooling of the critical regions e.g. rotor conductors; these developments have necessitated detailed examinations of the fluid flow behaviour within rotors, stators, exciters etc, and have highlighted some aspects which need further investigation.

This paper surveys the present state of the art of turbogenerator design and describes some of the problems confronting the next generation of turbogenerators.

A. Williams, Monash University

Abstract

This paper surveys the problems of fluid flow in the coolant systems of large electrical turbogenerators. These problems arise from the need to maintain safe working temperatures of components subjected to high rates of internal heat generation, and are inextricably linked with the associated problems of heat transfer. In present day turbogenerators the cooling fluids normally used are hydrogen (for the rotor conductors and the stator core) and water (for the stator conductors), and the balancing of the coolant flows to their respective heat loads necessitates an accurate knowledge of the flow characteristics of each individual flow path. Proposed designs using water cooled rotors show potential improvements, but at the expense of severe mechanical problems and uncertainties regarding flow behaviour under the extremely high centrifugal accelerations of the rotating system.

The paper examines two types of design of flow systems in stator cores, one having mainly axial flow, the other mainly radial. The influences of these two types on the design of the circulating fans are described. The stator core end plates usually require special consideration in view of the locally high magnetic losses.

The rotor conductor cooling system is often the crucial component of the turbogenerator, as the restricted space available for the copper conductors usually determines the maximum pressure for which the fan must be designed. Systems of direct cooling using either subslots or uniflow paths are described herein.

The annular region between rotor and stator usually collects the exhaust flow of coolant from the rotor and sometimes from the stator. The gas flow in the annulus is subjected to high rates of rotation superimposed on substantial axial components of velocity, and detailed knowledge of the flow is often uncertain. Fortunately this region is not subjected to high heat losses during normal operating conditions of the machine. However, during certain fault conditions, especially line to earth short circuits, there are extremely high losses near the surface of the steel rotor, and it becomes necessary to predict the local flow patterns and heat transfer coefficients in order to be able to design adequate protection equipment for the machine.

Circulating fans of either axial or centrifugal types are an integral part of the rotor system, usually mounted adjacent to one or both of the rotor conductor end support bells. Although in service the fans operate in an atmosphere of pressurised hydrogen, they are initially designed for, and tested in, appropriately simulated flow conditions of a normal atmospheric environment.

The paper attempts to bring together the features of fluid flow imposed by the major components and to show their interactions.