Regional Perspective of Shunt Reactor Introduction in the Transmission System

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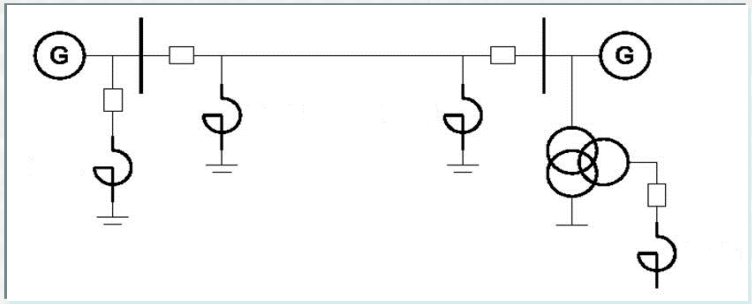
Regional Perspective of Shunt Reactor Introduction in the Transmission System

CONTENTS

- Introduction
- General design concepts
- Shunt reactor switching
- Shunt reactor reliability
- Switching and life management

INTRODUCTION

- Shunt reactors stabilize the voltage during load variations in high voltage transmission or cable systems.
- Shunt reactors connected by Bus, by Line, on Transformer Tertiary Winding, for mainly two reasons :
- To limit the overvoltages and to limit of reactive power in the network



INTRODUCTION

The main type of Shunt Reactors are :

- Air-core dry-type are normally connected to the tertiary winding of the high voltage transmission transformers, or can also be directly connected to the line system.

- Magnetic core type are : (WG A2.48) with Core form

1. Gapped-Core (mostly used)
2. magnetically shielded

with shell form mostly magnetically shielded

GENERAL DESIGN CONCEPTS

GAPPED-CORE TYPE

Shunt reactors contain same components as power transformers.

The fundamental difference is that the reactor core limbs have non magnetic gaps inserted between packets of core steel (gapped core) to avoid saturation of the core. This difference makes shunt reactors complicated.

Small gaps have low fringing losses but higher price, a few large gaps have lover price but higher fringing losses.

GENERAL DESIGN CONCEPTS

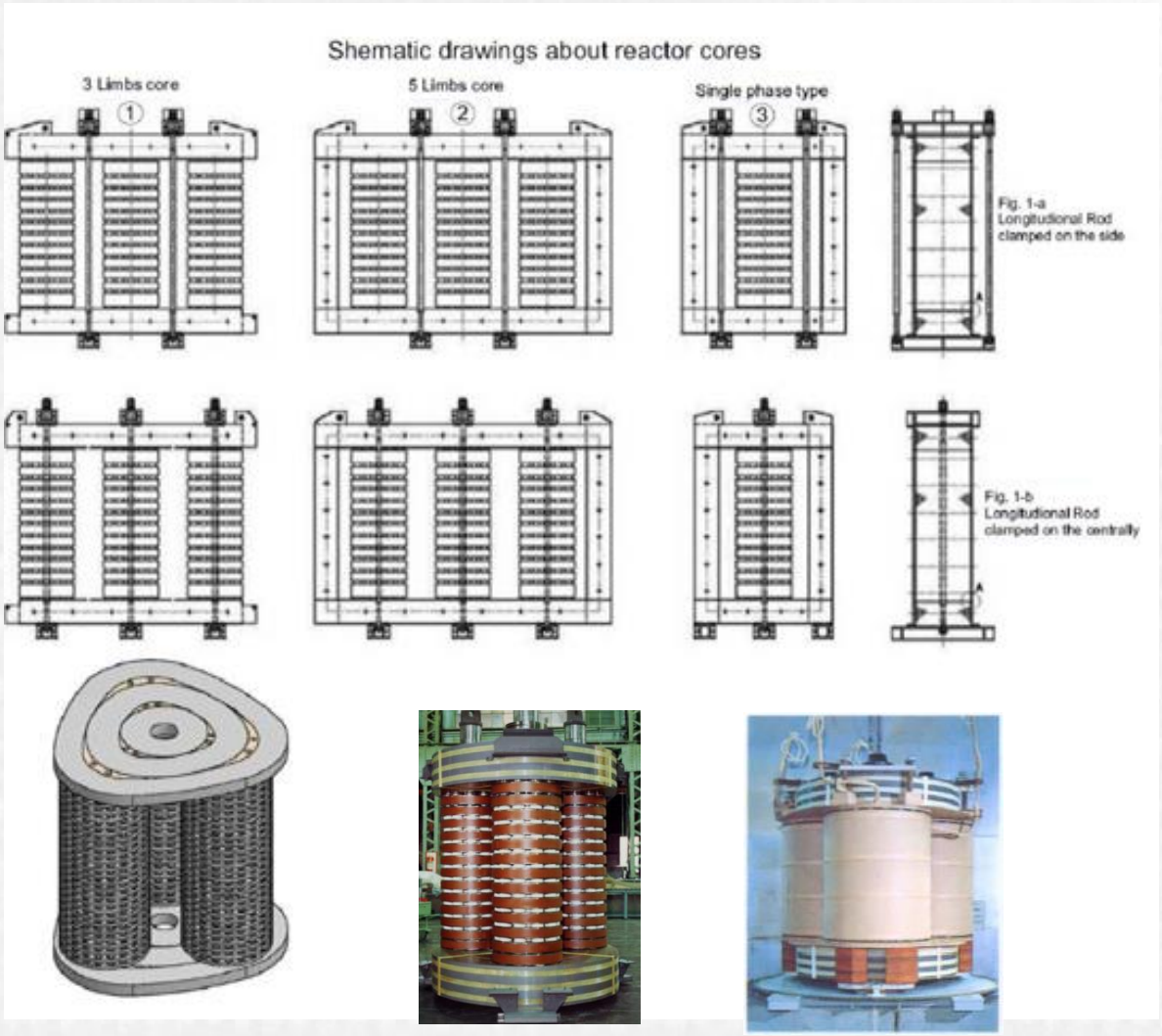
The Advanced design and production technology can ensure the product has low loss and low noise level.

DESIGN REVIEW (accord. WG A2.48)

Should examine the functionality of the shunt reactor with following important Particular:

- Application
- Network Location
- Switching
- Construction
- Noise and vibration
- Testing

GENERAL DESIGN CONCEPTS



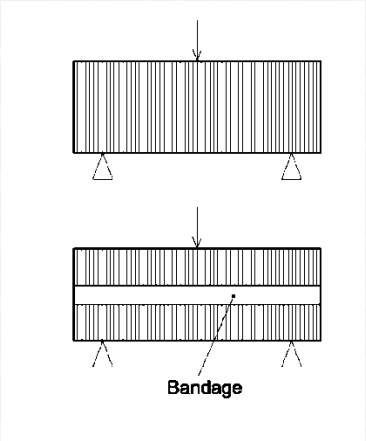
GENERAL DESIGN CONCEPTS

Shunt reactor cores from production line

GENERAL DESIGN CONCEPTS

Core Limbs must be robust enough against short circuits.

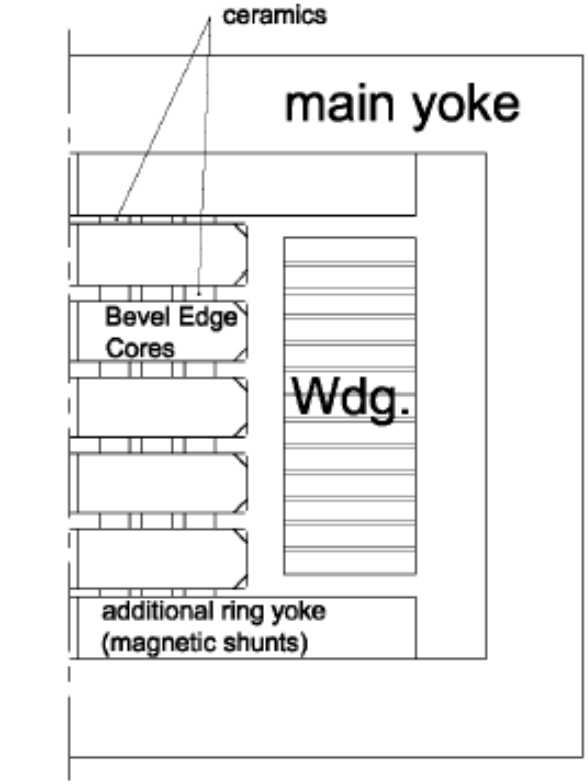
In order to confirm it mechanical shock test is performed



Result of the tests are specified that the core packets with glass bandage compare with non bandage have approximately double mechanical strength.

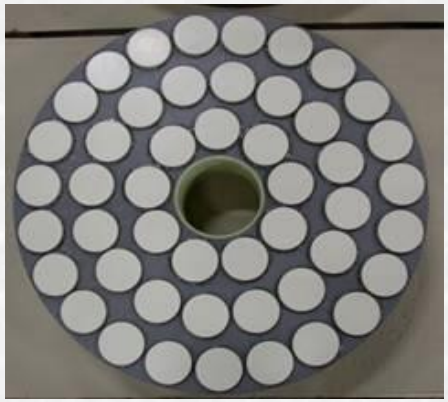
GENERAL DESIGN CONCEPTS

In new advanced designs BEVEL EDGE core packets are used to reduce the EDDY CURRENT LOSSES



GENERAL DESIGN CONCEPTS

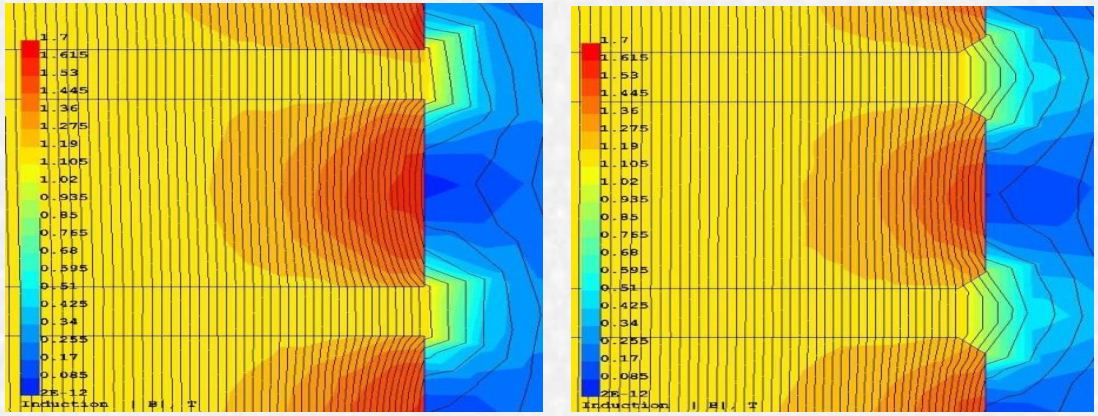
In big powers loss differences are remarkable,particularly in single phase



GENERAL DESIGN CONCEPTS

The radially stacked laminations prevent fringing flux from entering flat surfaces of core steel, thereby avoiding overheating on the core packed and the winding. For this reason gap size must be decided very carefully.

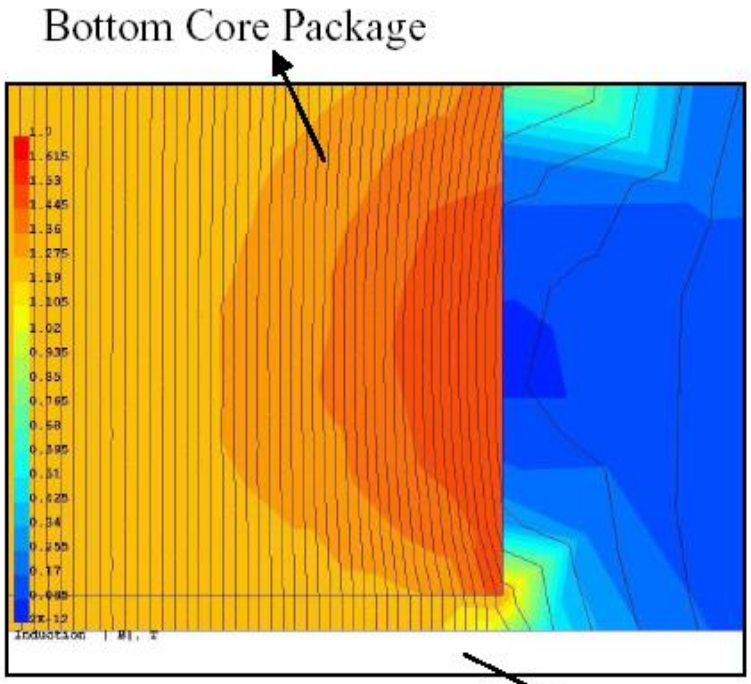
BY BEVELING CORE LIMB PACKETS THE EDDY CURRENT LOSSES ARE REDUCED



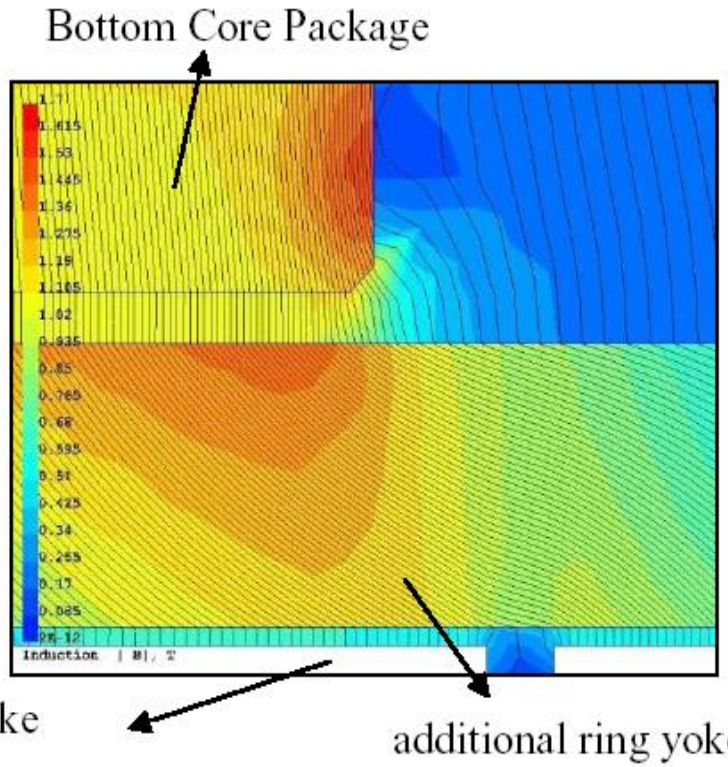
Two simulation pictures shows the differences between core packets without and with Bevel Edge

GENERAL DESIGN CONCEPTS

BY USING ADDITIONAL RING YOKE (SHUNTS) THE ADDITIONAL LOSSES ARE REDUCED



Core Package without Bevel Edge



Core Package with Bevel Edge and with Additional ring yoke

GENERAL DESIGN CONCEPTS

Additional Ring yokes (shunts), special flux plates also act as winding press plates. But also provide at top and bottom of winding to collect the leakage flux, thereby minimizing stray losses in tank and eddy current loss, Consequent hot spot at the end discs of winding.

Rectangular additional yokes can not have the same result of additional ring yokes.

GENERAL DESIGN CONCEPTS

SHUNT REACTOR SOUND AND VIBRATION

Shunt reactors are high level of sound source. One part of the sound is caused by the leakage flux field. Leakage flux in structural components produces forces and these forces create vibration. Vibration of the active part create local overheating and damage the Insulation. Vibration of the tank create leakages.

Following solutions can reduce the sounds and vibrations :

- Resonant plates attached to the tank wall
- Double-walled tanks
- Thicker tank wall
- Exterior sound panels (can reduce the sound level up to 6-10 dB.) See Ref.11

GENERAL DESIGN CONCEPT

The vibration level test is carried out in accordance with IEC 60076-10-1.

Noise and vibration in shunt reactors are generally higher than transformers of the same voltage class and rated power and thus require special consideration.These are generally:

Precision in the manufacturing process,robust design,durable material for long term stability.

GENERAL DESIGN CONCEPTS

Windings of a gapped-core reactor

SHUNT REACTOR SWITCHING

Shunt Reactor Switching is a unique duty. Several switching techniques have been developed.Circuit breakers are used typically to switch shunt reactors.

Shunt Reactor Switching is a daily frequently operation and is an onerous switching duty for circuit breakers. It force two types of overvoltages on the shunt reactor:

- Suppression peak overvoltage at current interruption and
- in the event of a re-ignition leading to another loop of power frequency current

(for more info., Dr. David Peelo, CIGRE, SC A3.Workshop/ Tutorial, Sept. 23/2015, Shanghai/China)

SHUNT REACTOR SWITCHING

SWITCHING AND CONTROLLING OF SHUNT REACTORS

- Fixed shunt reactor, a fixed inductive reactance is switched in or out with a circuit breaker,coarse adjustment through parallel combinations of several reactors
- Variable shunt reactor (VSR) with on-load tap- changer inductive reactance can be changed step by step a certain range.Precise tapping of one reactor.Other advantages:

  -increased grid reliability and improved voltage quality

  -reduced investments and operating costs

  -also suitable for urban areas-quite and space-saving

  -reduced operating noise

  -reduction of the maintenance cost

SHUNT REACTOR SWITCHING

SWITCHING AND CONTROLLING OF SHUNT REACTORS

- Magnetically controlled shunt reactor (MCSR) is a new type used for flexible AC transmission system.Mostly used in CIS Countrys.Principle of operation is extremely high saturation of the magnetic core.

  MCSR complex consist of folloving parts:

  -elektromagnetic part of a transformer

  -magnetizing system

  -automatic control system

  Need of more space requirements and planning work

SHUNT REACTOR RELIABILITY

CIGRE WG A2.48 have managed to obtain some reliability data for shunt reactors, from 2 countries including detailed information (Australia and Great Britain). This info will be published separately by CIGRE WG.

Australian Experience: The most common failure location is bushings, by a wide margin.

Great Britain: The most common failure location is windings, by a wide margin.

Available evidence agrees that the most common failure mode by far is Dielectric. Other failure modes include mechanical and thermal.

More info about this subject :

CIGRE SC A2 Colloquium 2015 sept.20-25 Shanghai

Paper from Simon Ryder, CIGRE WG A2.48

'Shunt Reactor Reliability'

SHUNT REACTOR RELIABILITY

Switching, protection, control and monitoring systems need to be adapted to the special requirements of shunt reactor. See WG B5.37 brochure 546

SWITCHING AND LIFE MANAGEMENT

The below given references provide specific details associated with the control and switching of shunt reactors :

- CIGRE 2008 Paper A2-304, Stresses on shunt reactors due to switching
- CIGRE 2006 Paper A2-301,Assessment of an EHV shunt reactor insulation and mechanical performance by switching surge analyses
- CIGRE brochure 546,Protection monitoring and control of shunt reactors
- CIGRE brochure 50,Interruption of small inductive currents
- IEEE standard C37. 015,IEEEguide for the application of shunt reactor switching
- CIGRE brochure 305,Guide for application of IEC 62271-1 and -100

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[4] S.Yürekten, How to reach the quality excellence in transformer technology with tailor-made components, Travek 8-9 November 2011,Moscow

[5] R.Ahuja, R.M.Del Vecchio, Transformer stray loss and flux distribution studies using 3D finite element analysis, Waukesha Electric Systems, USA

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[8] S.Yurekten, Trend in the recent improvement of gapped-core UHV shunt reactor design, CIGRE International Colloquium, New Delhi,3-4 April 2013

[9] S.Yurekten, K.Eckholz, Shunt reactor Cores up to 800 KV.-300 MVAR. ARWtr 2010,Advanced Research Workshop on Transformers,3-6 October 2010 Santiago de Compostela Spain

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[11] C.Ploetner, Sound Levels of Oil-immersed Shunt Reactors Development-Prediction-Specification, CIGRE WG A2.48, Sep.20-25 /2015 China

Thank You
For Your Attention