THE LOSS REDUCTION WITH ADDITIONAL RING YOKES IN UHV SHUNT REACTORS

by

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SHUNT REACTOR APPLICATION IN NETWORK SYSTEM

- Shunt reactors are an essential part of HV-UHV networks and used for:
  - Compensation of capacitive reactance of transmission line or cables,
  - Reduction of the overvoltage along the line and stabilizing the system voltage within acceptable limits, so-called ‘Ferranti effect.’

- Connected:
  - By line (on the beginning-on the end)
  - By bus
  - On transformer Tertiary winding
IRON CORE SHUNT REACTORS

- There are 2 type shunt reactors:
  - 1. With radially laminated iron core divided by air gaps
  - 2. Without iron core, with magnetic return circuit
- Iron core (Silicon steel) types have less losses, less noises and smaller dimensions

The philosophy of the shunt reactor core design is to minimize losses, temperature, sound and vibration

Losses: Eddy current losses, additional (Structural) losses, copper losses
FRINGING EFFECT

- Fringing flux is completely around the gap and effect a function of gap dimension and increase the inductance.
- So it will induce eddy current that will cause localized heating.
- Small gaps have low fringing losses.
- Higher fringing losses=higher cost.
- During the life of reactor.
BEVEL EDGE IN CORE PACKETS

In new advanced design, BEVEL EDGE core packets are used to reduce the EDDY CURRENT LOSSES. The eddy losses are commonly calculated 2-D simulations.

I gave in my previous papers with this respect to enough detail info. Due to beveling the edges in core blocks, the eddy current losses and sound level are reducing.

Additionally, saturation point is increased due to average flux density and inductance is reduced. Graph 1 shows the comparison.
BEVEL EDGE IN CORE PACKETS

- The simulation in Figure shows the difference

**BY BEVELING CORE LIMB PACKETS THE EDDY CURRENT LOSSES ARE REDUCED**

Graph 1. Saturation Curves

Two simulation pictures shows the differences between core packets without and with Bevel Edge
ADDITIONAL RING YOKE (SHUNTS)

Additional ring yokes (shunts) are installed at the bottom and above of the core limbs in order to collect main and stray fluxes. This advanced solution is not comparable with the simple cornered shunt.

Stray fluxes create stray losses. With this solution the additional (structural) losses and the copper losses can be reduced.
Without additional ring yoke

With additional ring yoke
ADDITIONAL RING YOKE (SHUNTS)

- The stray fluxes create stray losses. Additional ring yokes collect main and stray fluxes which go out from windings.

BY USING ADDITIONAL RING YOKE (SHUNTS) THE ADDITIONAL LOSSES ARE REDUCED
Distribution of the flux density in reactor cross-section for core type 1/2 (Without Additional Ring Yoke)

Distribution of the flux density in reactor cross-section for core type 1/2 (With Additional Ring Yoke)

Rectangular shields can not have same result of additional ring yokes
Distribution of the flux density in reactor cross-section for core type 3/2
(Without Additional Ring Yoke)

Distribution of the flux density in reactor cross-section for core type 3/2
(With Additional Ring Yoke)
CASE STUDY RESULTS

• Calculation results of reactor cores in different power
• By calculation program we have following results, (without guarantee):
  • A. 1 Phase: (in UHV level used mostly 1 phase)
    • 80 MVAr/800 kV loss 121/112 kW. saving 9 kW 7,5%
    • 100 “” “” loss 133/123 kW. saving 10 kW 7,5%
    • 240 “” “” loss 288/275 kW. saving 13 kW 4,5%
    • 280 “” “” loss 312/295 kW. saving 17 kW 5,5%
  • B. 3 Phase
    • 150 MVAr/400 kV loss 256/250 kW saving 6 kW 2,4%
    • If we consider international rules of the loss capitalization of the reactor we can see that the loss saving rates are very high
CASE STUDY RESULTS

‘CIGRE A2-204 (2012) Energy Efficient Transformers and Reactors’ give the report of that:

One-third of T&D losses are in Transformers and Reactors

For energy efficient shunt reactor design:

The capitalized cost of losses may vary from 8000 Cu to 17000 Fe Eu/kW.

For typical shunt reactor design:

From 2157 Cu to 4200 Fe Eu/kW.
CASE STUDY RESULTS

- Distribution of the temperature fields in reactor cross-section
- Additional ring yoke and bevel edge prevent high temperature rising on core by reducing average magnetic flux density
- Temperature rise in 80 MVAr 765 kV 1 Ph reactor core
CONCLUSION

• New advanced design and precision in manufacturing process can ensure the product has low loss, low noise and low temperature.

• Simulations show that: Core blocks with bevel edge and additional ring yokes are advanced solution for reducing of losses and temperature.

• According international rules of the loss capitalization of the reactors due to new manufacturing processes (bevel edge core packet and additional ring yoke) loss saving rates are very big.