A Hybrid Compensation Method for ICT High Voltage Power Supply

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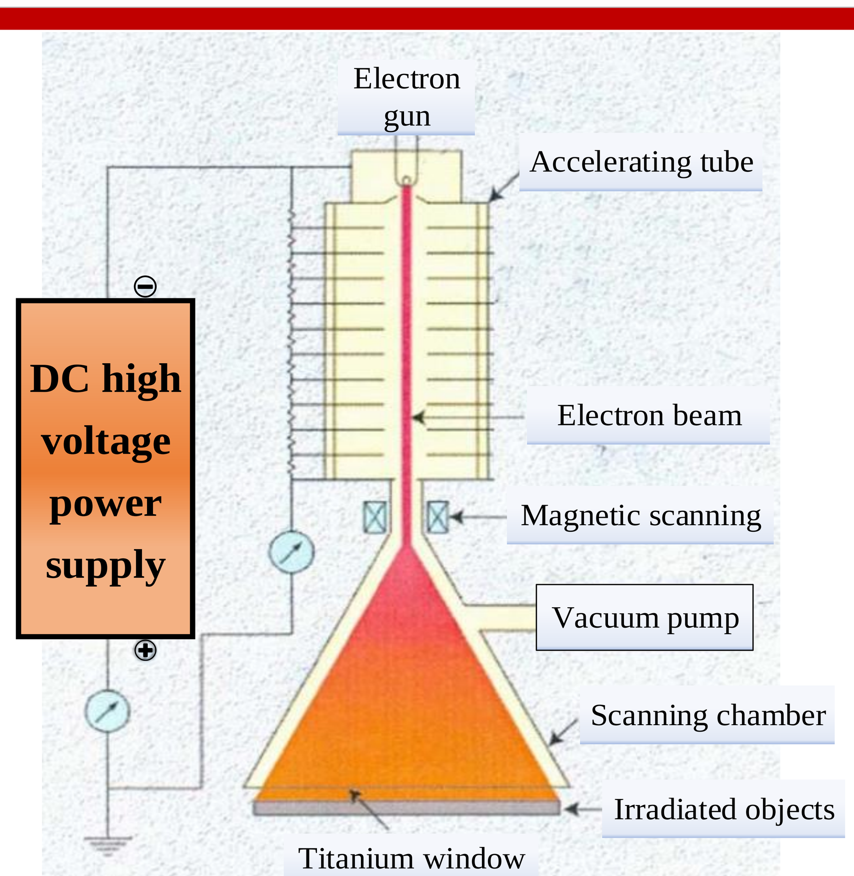
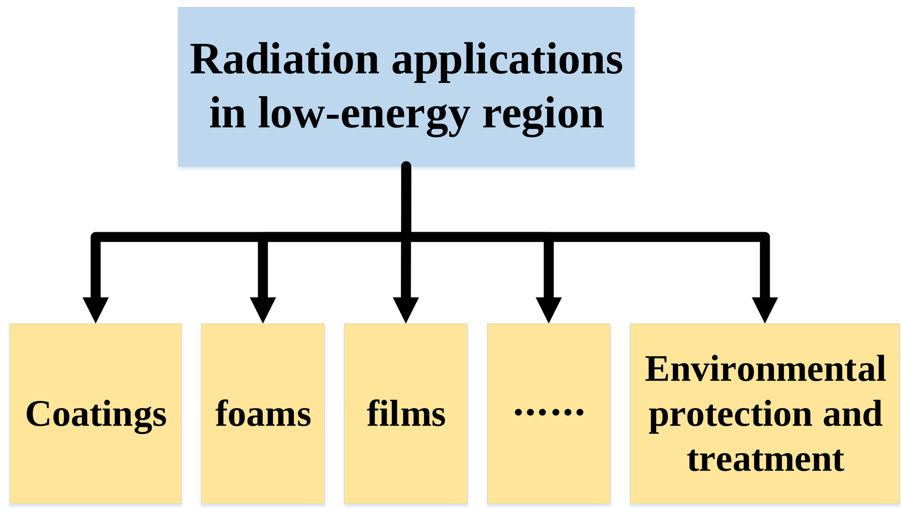


Fig. 1. The structure diagram of E-beam system.



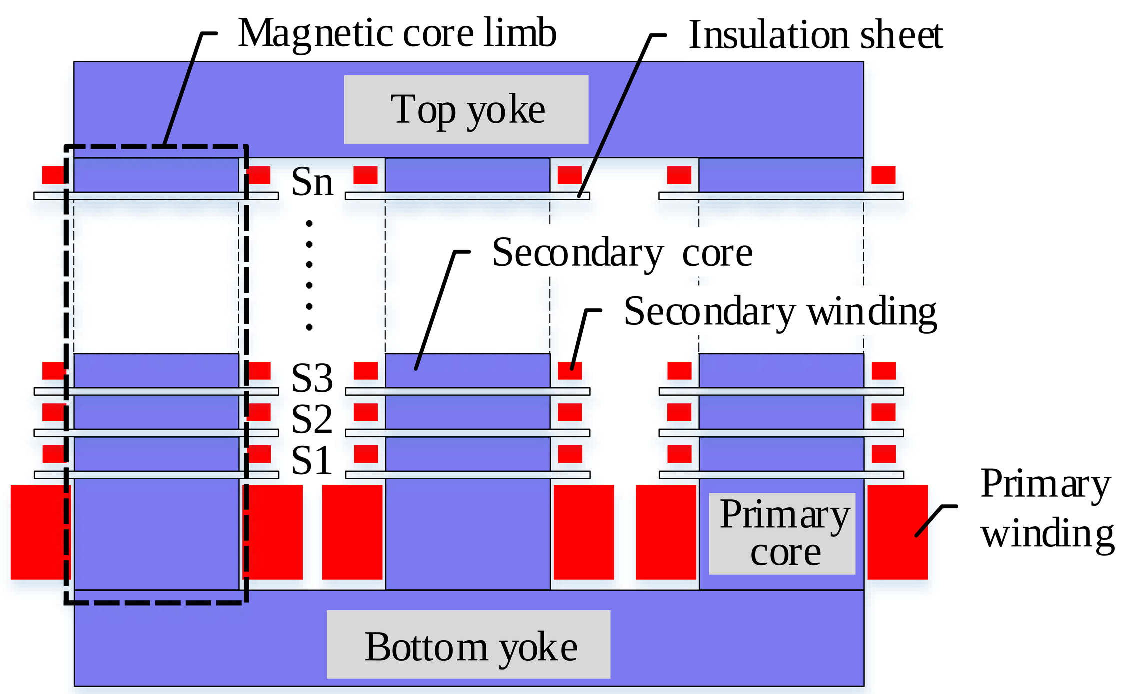


Fig. 2. The cross-section view of traditional ICT structure.

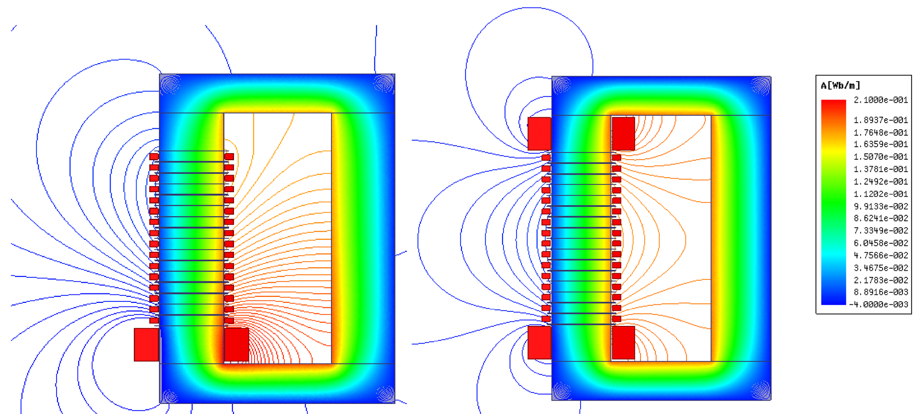


Fig. 3. The distribution of magnetic field lines in 2D model, (a) without dummy primary winding, (b) with dummy primary winding

Introduction

- In recent years, the applications in low-energy region (<1 MeV) has been developing very fast. The structure diagram of E-beam system is shown in Fig. 1.The high voltage generator is the most important component of electron accelerator.

The main concern in low-energy region:
① High voltage breakdown
② Compact structure
③ High efficiency

The segmented core structure of ICT is a good scheme

New problem: a large magnetic flux leakage (MFL)

A hybrid compensation method is used to reduce MFL

Improve the uniformity of the disk output voltage

The advantages of ICT power supply:
- high efficiency
- high-power output
- high reliability
- compact structure
- low cost

Objective: A good uniformity of the disk output voltage.

- ✓ Space requirements minimized
- ✓ Compact structure
- ✓ Improve the electrical field distribution
- ✓ Increase the utilization of the rectifier components
- ✓ Improve the reliability

- The ICT electron accelerator is a superior type of accelerators in low-energy region.

- **The traditional ICT structure**
  - The main magnetic pass: primary cores, secondary cores, top yoke, bottom yoke, insulation sheets, primary windings, secondary windings.
  - Electric circuit: a bridge voltage doubler

The hybrid compensation method for an 800kV/50mA ICT

- **The new structure**
  - Add three dummy primary windings at the top of the limbs based on the traditional ICT as Fig. 4.
  - A capacitor is connected with each winding in parallel.
- **The hybrid compensation method**

① Assume a random turns (Np’) of the dummy winding, and calculate the matrix with capacitance (C) and turns (N1 , N2 , N3 , …, Nn)

② Adjust Np’ to make sure U1_no-load ≈Un_full-load, and Un_no-load ≈ U1_full-load.

③ Adjust C at the suitable Np’ to reach a better uniformity of disk voltage in no-load and full-load.

④ Adjust N_1, N_2, N_3, …, N_n through multiple iterations to reach an optimum uniformity of disk voltage in no-load and full-load.

Discussion

- **The turns standardization of secondary windings**

The turn standardization of windings can help to reduce the specifications of all the secondary windings, and decrease the cost and difficulty of the producer to process and install the windings.

The non-uniformity is better than 6.8% when the types of the secondary windings are reduced from 16 to 8. The result is shown in Table II.

- **Parameters optimization with Genetic Algorithm**

It is inefficient by manually adjust parameters. In future work, genetic algorithm will be used to find a more optimal solution automatically.

Conclusion

① A hybrid compensation method is proposed to improve the non-uniformity.

② The model of an 800 kV/50mA ICT power supply is developed as an example. The analysis are mainly based on the evolution Np’, N1, N2, N3, …, N16 and C. The results verifies successfully the validity of the hybrid compensation method.

③ Furthermore, the standardization for winding turns is discussed, the non-uniformity is better than 6.8% from no-load to full-load with eight specifications of windings.

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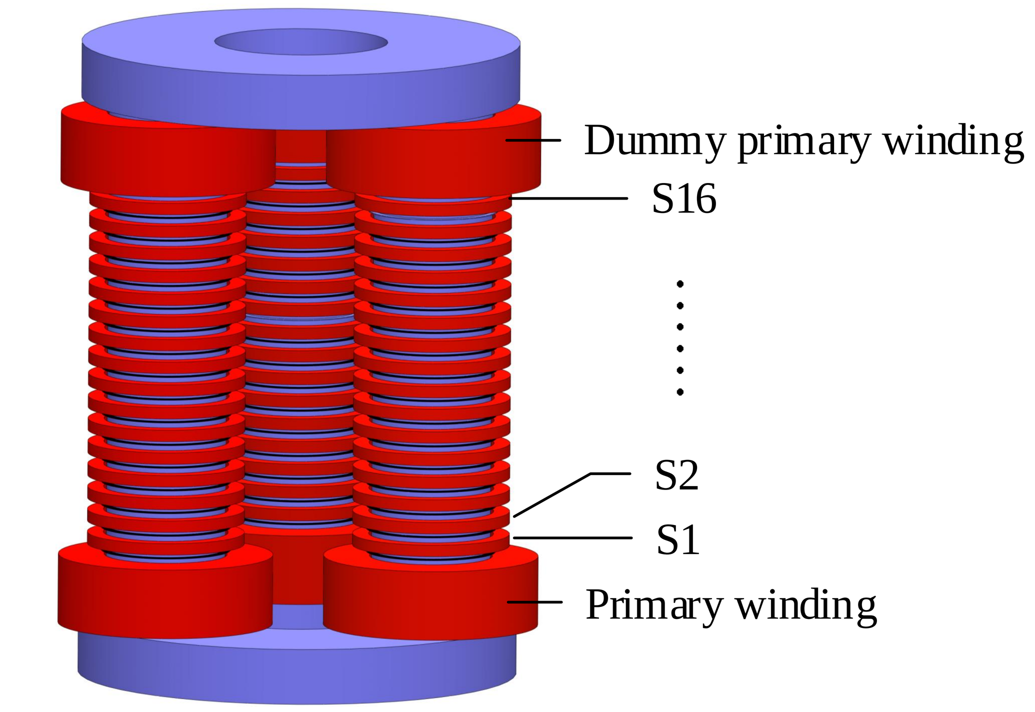

Fig. 4. Three-dimensional ICT structure with dummy primary windings.

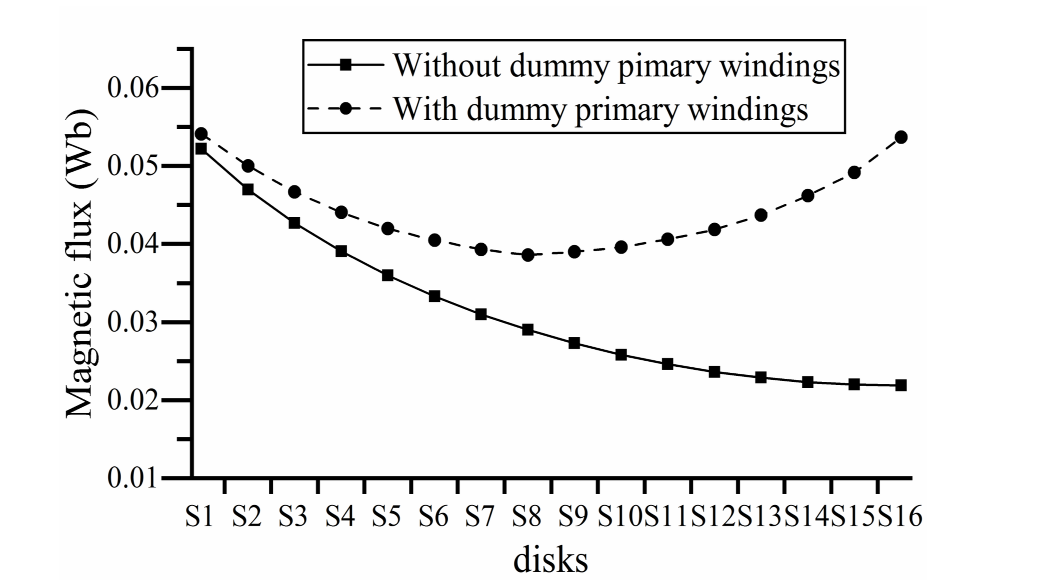

Fig. 5. The magnetic flux distribution of single-turn secondary winding of the phase A.

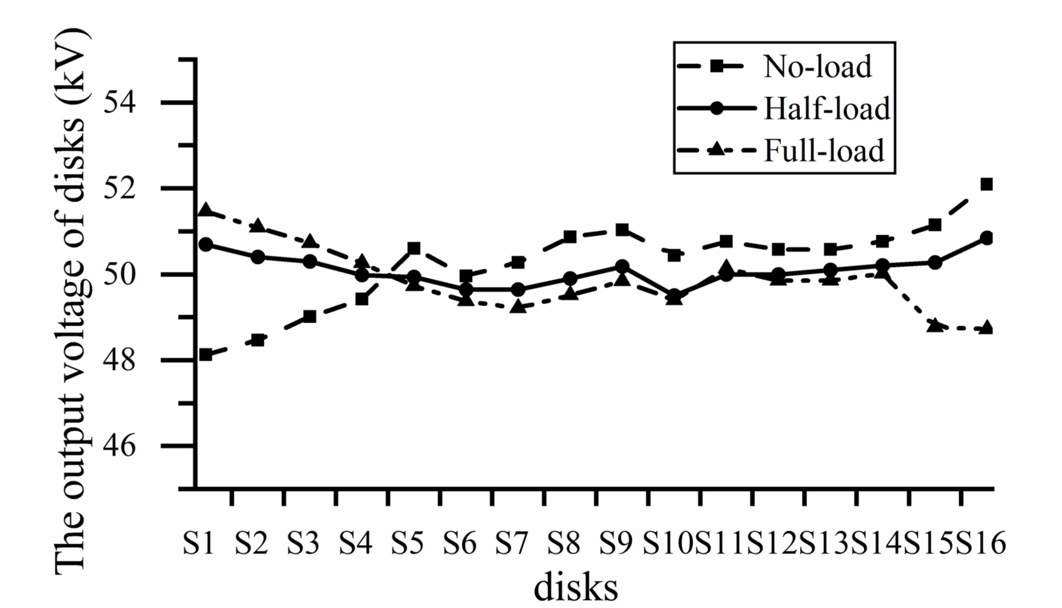

Fig. 6. The structure diagram of E-beam system.

TABLE I The optimized turns of secondary windings

Disk No.	The number of turns	Disk No.	The number of turns
S1	960	S9	1370
S2	1060	S10	1350
S3	1140	S11	1310
S4	1210	S12	1250
S5	1270	S13	1200
S6	1350	S14	1140
S7	1370	S15	1060
S8	1390	S16	980

TABLE II The standardized secondary winding number of turns

Disk No.	The number of turns
S1	965
S2/S15	1060
S3/S14	1140
S4/S13	1210
S5/ S12	1280
S6/ S11	1360
S7-S10	1400
S16	985