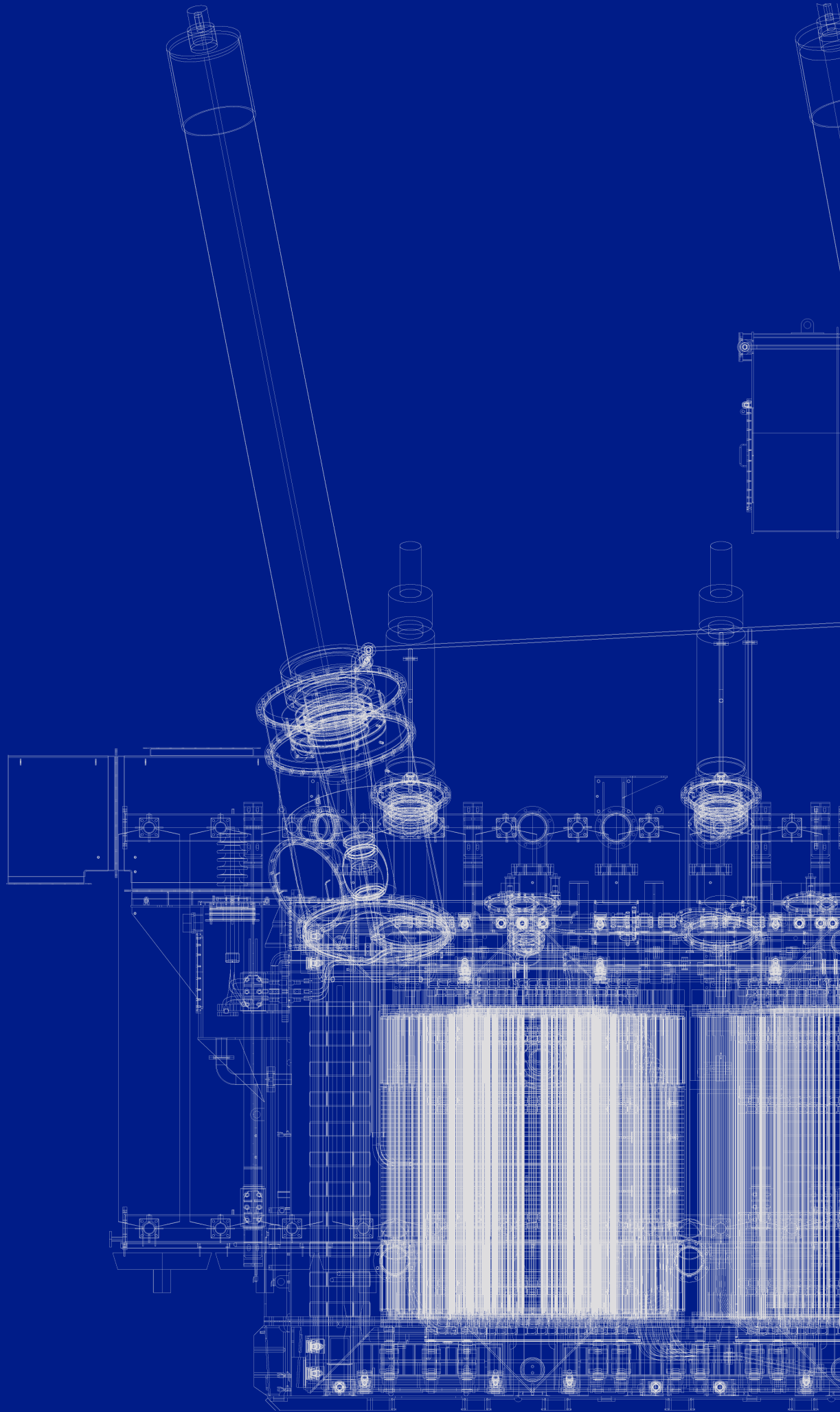
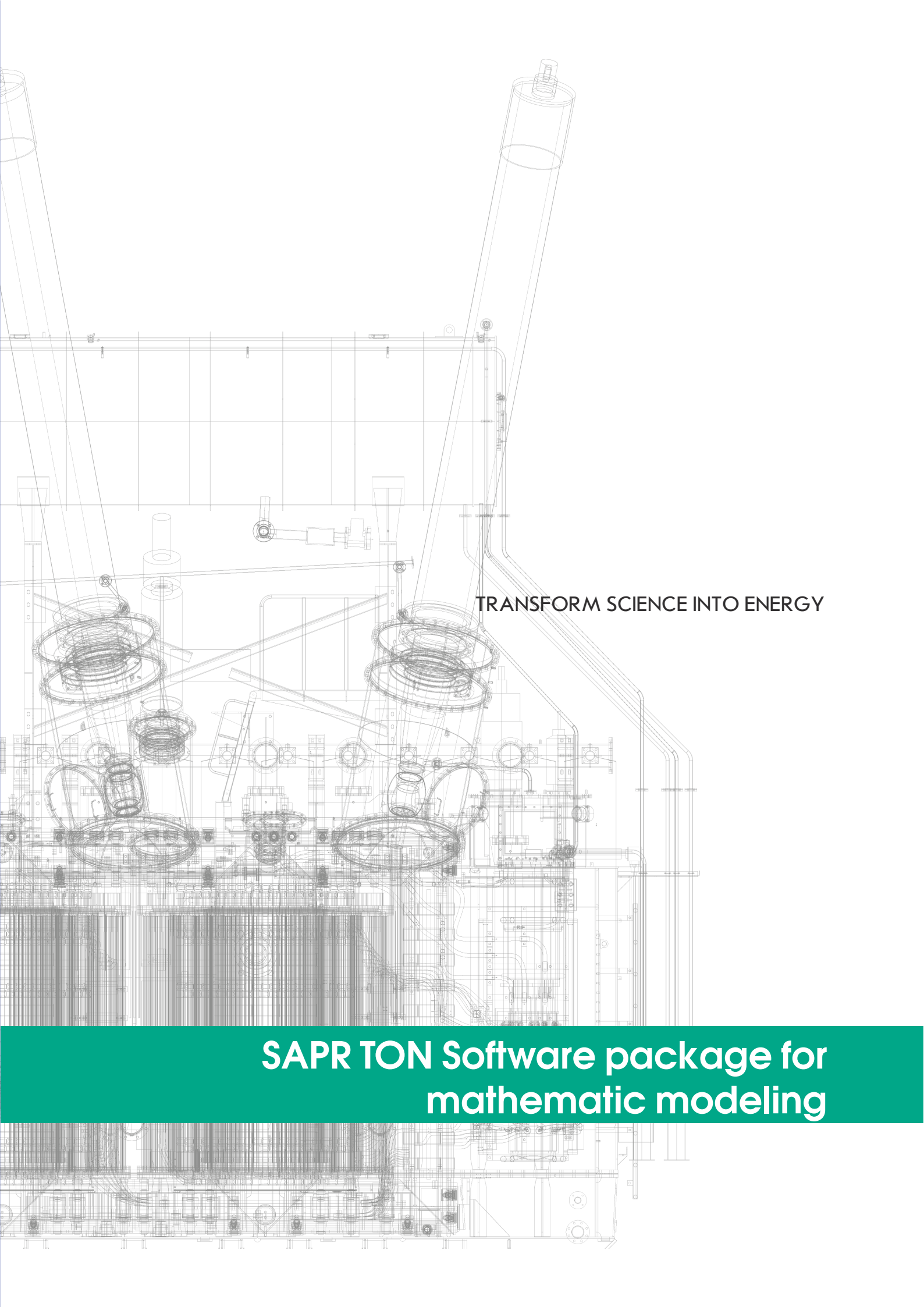


SAPR TON

Software package for
mathematic modeling





TRANSFORM SCIENCE INTO ENERGY

**SAPR TON Software package for
mathematic modeling**



SAPR TON Software package for mathematic modeling is intended for design investigations, optimization of design solutions and main dimensions, determination of technical and economic characteristics of general-purpose power transformers and autotransformers



PRT

Design synthesis of transformer optimal design

Program of design synthesis of 110–1150 kV, 2.500...1000 MVA transformer (shortly – PRT) can be used during design and optimization investigations of power transformers at the stages of tender offers for choosing of optimal variant of transformer and determination of its main characteristics (main dimensions of magnetic system and windings, as well as weight, energetic and economic characteristics) under electric parameters of centres, dimensions of insulation gaps, short-circuit voltage of the basic pair of windings, specific electromagnetic loads specified to design scheme.

The program covers single- and three-phase multi-winding transformers and autotransformers with flat-laminated magnetic circuit, helical and cylindrical (including regulating), layer and coil windings made of rectangular copper or aluminum wire with terminal at the end or in the middle, arbitrarily located in one or several legs of magnetic circuit or arbitrarily connected.

The program covers single- and three-phase multi-winding transformers and autotransformers with flat-laminated magnetic circuit, helical and cylindrical (including regulating), layer and coil windings made of rectangular copper or aluminum wire with terminal at the end or in the middle, arbitrarily located in one or several legs of magnetic circuit or arbitrarily connected. The windings can be located on the side yokes. Coil windings can be made of two types of wires (zone of wire of the second type can be arranged at the end (ends) of windings in the middle or specified distance from the end. Coils of the second zone can be splitted. Additional zones can be of the following types: laminated zone of combined coil centre (I), input zone of the other type wire (E), regulating zone (R), zone with dead turns (C) for splitted centre with different currents and voltages the centre part belonging to the other voltage side (S). For splitted centres it is possible to specify "oblique" modes ($LV1 > HV$, $LV2 > HV$) and also mode with splitted windings ($LV1 > LV2$). The axial ducts can be made in additional zone. Number and dimensions of the axial ducts can be different from axial ducts in the main zone. Radial cooling ducts in two zones can be different. Winding or its additional zone can be made of particular specified wires in such case reactances can be different from the specified tolerance for Ushort-circuit. In regulating windings the regulating steps can be arranged both in axial and radial directions. The windings can be made of simple rectangular wire (REC), subdivided wire (SUB), transposed wire with or without gluing (CTC). The wire material is determined by assignment of specific resistance at 20°C and can be copper or aluminum or copper alloy. Specifying of additional protective insulation (L – from the wire left side, R –from the wire right side etc.) is ensured for transposed wire.

The program enables to specify number of parallel wires in axial and (or) radial directions as well as number of coils in centre or layers in multi-layer centres. The result printout provides the figure of arrangement of windings on the leg with indicated main dimensions of windings and main gaps. Short-circuit losses, main and added losses due to axial and radial field are calculated in all specified modes. Short-circuit voltage in modes with decreased power can be reduced both to higher and lower power of voltage sides. Several normalized short-circuit voltages can be specified for three-winding transformers. Laying out of centres is performed by the program under the first specified short-circuit voltage of the main mode. In case of multi-variant calculation the program doesn't enter in table of calculated variants those variants in which the main value U_k doesn't correspond the specified normalized value U_k .

Program performs the following functions in dialog mode:

- entering of initial data from tables filled by the user; projects are saved in working archive, explanations and rules for filling (Help) are provided to all parameters of all tables with initial data;



- control of initial data and occurrence of diagnostic messages;
- making one calculation or the specified quantity of variants;
- determination of the main dimensions of magnetic system and centres, selection of wires and arrangement of centres, calculation of no-load and short-circuit losses, short-circuit voltages in the specified modes, weight characteristics, cost of active materials, estimation of average overheatings of centres and reserves of radial stability and strength of centres to be pressed during short-circuit for each variant of calculation;
- output of initial data and calculation results on display and printer;
- repeated calculation of any selected variant from the table of calculated variants for obtaining of detailed results of calculation;
- reference information (including wire gage, characteristics of si-steel etc.) entered into reference data base and available for correction by system administrator.

Initial sorting of calculated variants in table of the main characteristics of variants is made under capitalized costs. If Table "Prices" is not specified the initial sorting of calculated variants is made under total weight of si-steel and wire. User can make their sorting under any of parameters of the table, select variants with characteristics within limits specified by the user.

Общие данные

Число фаз	Номинальная мощность, МВА	Частота, Гц	Тип системы охлаждения	Суммарные потери в оловцах, кВт	Форма бака	Коэффициент мощности вторичной цепи
3	8000	50	ONAF		RECTANGULAR	

Всё варианты

V	Кап. затр. в т.о.в.	Кап. затр. [%]	Стоим. матер. [т.о.в.]	Стоим. матер. [кВт]	Дс [мм]	Вс [Тл]	Рх [кВм]	Ро [кВм]	Рсв [кВм]	Gcm [кВ]	Gcp [кВ]	Gcm+Gcp [кВ]	Gmp [кВ]	Ho [мм]	Hb [мм]	Тем. м.о.в. [с.с.]	Тол.масса [кг]	кВт	P [РБ]	Уд [кг]	Uct [кВ]
1	908.24	103.68	908.24	103.68	415	1.66	41.72	0.51	50.23	6336	2352	8688	18328	929	1919	60	18.9	0.07	109.3	7.76	9
2	918.2	102.34	918.2	102.34	415	1.66	42.52	0.5	51.02	6321	2277	8598	18199	929	1919	60	19.6	0.07	109.3	7.68	9
3	918.2	102.34	918.2	102.34	415	1.66	42.52	0.5	51.02	6321	2277	8598	18199	929	1919	60	19.6	0.07	109.3	7.68	9
4	918.2	102.34	918.2	102.34	415	1.66	42.52	0.5	51.02	6321	2277	8598	18199	929	1919	60	19.6	0.07	109.3	7.68	9
5	920.39	102.58	920.39	102.58	415	1.66	43.05	0.51	51.57	6336	2277	8612	18266	929	1919	60	19.7	0.08	109.3	7.84	9
6	920.39	102.58	920.39	102.58	415	1.66	43.05	0.51	51.57	6336	2277	8612	18266	929	1919	60	19.7	0.08	109.3	7.84	9
7	920.39	102.58	920.39	102.58	415	1.66	43.05	0.51	51.57	6336	2277	8612	18266	929	1919	60	19.7	0.08	109.3	7.84	9
8	920.39	102.58	920.39	102.58	415	1.66	43.05	0.51	51.57	6336	2277	8612	18266	929	1919	60	19.7	0.08	109.3	7.84	9
9	920.39	102.58	920.39	102.58	415	1.66	43.05	0.51	51.57	6336	2277	8612	18266	929	1919	60	19.7	0.08	109.3	7.84	9
10	914.15	101.59	914.15	101.59	415	1.66	42.31	0.49	51.6	6316	2251	8587	18206	929	1919	60	19.7	0.07	109.3	7.65	9
11	913.6	101.83	913.6	101.83	415	1.66	43.08	0.5	51.84	6328	2243	8571	18204	929	1919	60	19.7	0.05	109.3	7.85	9
12	913.6	101.83	913.6	101.83	415	1.66	43.08	0.5	51.84	6328	2243	8571	18204	929	1919	60	19.7	0.05	109.3	7.85	9
13	908.36	102.58	908.36	102.58	415	1.66	42.68	0.48	51.14	6309	2228	8537	18159	929	1919	60	19.6	0.07	109.3	7.55	9
14	908.36	102.58	908.36	102.58	415	1.66	42.68	0.48	51.14	6309	2228	8537	18159	929	1919	60	19.6	0.07	109.3	7.55	9
15	911.44	101.59	911.44	101.59	415	1.66	42.82	0.48	51.3	6309	2248	8555	18125	929	1919	60	19.6	0.07	109.3	7.63	9
16	911.44	101.59	911.44	101.59	415	1.66	42.82	0.48	51.3	6309	2248	8555	18125	929	1919	60	19.6	0.07	109.3	7.63	9
17	923.43	102.92	923.43	102.92	415	1.66	42.02	0.5	50.52	6324	2320	8645	18254	929	1919	60	19.0	0.08	109.3	7.71	1
18	911.44	101.59	911.44	101.59	415	1.66	42.82	0.48	51.3	6309	2248	8555	18125	929	1919	60	19.6	0.07	109.3	7.63	9
19	911.44	101.59	911.44	101.59	415	1.66	42.82	0.48	51.3	6309	2248	8555	18125	929	1919	60	19.6	0.07	109.3	7.63	9
20	913.63	101.83	913.63	101.83	415	1.66	43.34	0.5	51.84	6324	2245	8570	18191	929	1919	60	19.7	0.08	109.3	7.89	9
21	923.43	102.92	923.43	102.92	415	1.66	42.02	0.5	50.52	6324	2320	8645	18254	929	1919	60	19.0	0.08	109.3	7.71	1
22	911.44	101.59	911.44	101.59	415	1.66	42.82	0.48	51.3	6309	2248	8555	18125	929	1919	60	19.6	0.07	109.3	7.63	9
23	913.63	101.83	913.63	101.83	415	1.66	43.34	0.5	51.84	6324	2245	8570	18191	929	1919	60	19.7	0.08	109.3	7.89	9
24	913.63	101.83	913.63	101.83	415	1.66	43.34	0.5	51.84	6324	2245	8570	18191	929	1919	60	19.7	0.08	109.3	7.89	9
25	916.65	102.17	916.65	102.17	415	1.66	42.08	0.49	50.55	6317	2296	8603	18192	929	1919	60	19.0	0.05	109.3	7.62	9
26	920.48	102.63	920.48	102.63	415	1.66	42.85	0.48	51.33	6302	2312	8613	18203	929	1919	60	19.8	0.05	109.3	7.54	9
27	908.87	101.08	908.87	101.08	415	1.66	43.37	0.49	51.88	6317	2211	8528	18129	929	1919	60	19.7	0.05	109.3	7.79	9
28	908.87	101.08	908.87	101.08	415	1.66	43.37	0.49	51.88	6317	2211	8528	18129	929	1919	60	19.7	0.05	109.3	7.79	9
29	913.59	101.82	913.59	101.82	415	1.66	42.16	0.49	50.85	6315	2271	8584	18164	929	1919	60	19.0	0.07	109.3	7.58	9
30	901.64	100.49	901.64	100.49	415	1.66	42.95	0.47	51.43	6298	2197	8494	18035	929	1919	60	19.6	0.07	109.3	7.5	9
31	903.83	100.74	903.83	100.74	415	1.66	43.47	0.49	51.96	6313	2198	8509	18011	929	1919	60	19.7	0.07	109.3	7.75	9
32	907.41	101.14	907.41	101.14	415	1.66	43.6	0.48	52.07	6304	2220	8524	18122	929	1919	60	19.7	0.07	109.3	7.79	9
33	923.43	102.92	923.43	102.92	415	1.66	42.02	0.5	50.52	6324	2320	8645	18254	929	1919	60	19.0	0.08	109.3	7.71	1
34	911.44	101.59	911.44	101.59	415	1.66	42.82	0.48	51.3	6309	2248	8555	18125	929	1919	60	19.6	0.07	109.3	7.63	9
35	911.44	101.59	911.44	101.59	415	1.66	42.82	0.48	51.3	6309	2248	8555	18125	929	1919	60	19.6	0.07	109.3	7.63	9
36	913.63	101.83	913.63	101.83	415	1.66	43.34	0.5	51.84	6324	2245	8570	18191	929	1919	60	19.7	0.08	109.3	7.89	9
37	923.43	102.92	923.43	102.92	415	1.66	42.02	0.5	50.52	6324	2320	8645	18254	929	1919	60	19.0	0.08	109.3	7.71	1
38	911.44	101.59	911.44	101.59	415	1.66	42.82	0.48	51.3	6309	2248	8555	18125	929	1919	60	19.6	0.07	109.3	7.63	9
39	913.63	101.83	913.63	101.83	415	1.66	43.34	0.5	51.84	6324	2245	8570	18191	929	1919	60	19.7	0.08	109.3	7.89	9
40	913.63	101.83	913.63	101.83	415	1.66	43.34	0.5	51.84	6324	2245	8570	18191	929	1919	60	19.7	0.08	109.3	7.89	9
41	916.65	102.17	916.65	102.17	415	1.66	42.08	0.49	50.55	6317	2296	8603	18192	929	1919	60	19.0	0.05	109.3	7.62	9
42	908.87	101.08	908.87	101.08	415	1.66	42.95	0.48	51.33	6302	2312	8613	18203	929	1919	60	19.8	0.05	109.3	7.54	9
43	908.87	101.08	908.87	101.08	415	1.66	43.37	0.49	51.88	6317	2211	8528	18129	929	1919	60	19.7	0.05	109.3	7.79	9
44	908.87	101.08	908.87	101.08	415	1.66	43.37	0.49	51.88	6317	2211	8528	18129	929	1919	60	19.7	0.05	109.3	7.79	9
45	913.59	101.82	913.59	101.82	415	1.66	42.16	0.49	50.85	6315	2271	8584	18164	929	1919	60	19.0	0.07	109.3	7.58	9
46	901.64	100.49	901.64	100.49	415	1.66	42.95	0.47	51.43	6298	2197	8494	18035	929	1919	60	19.6	0.07	109.3	7.5	9



TOK

Calculation of current distribution in windings

Purpose

The program is designed for determination currents and voltages of transformer and autotransformer winding branches in complex multi-winding, multi-parallel or series-parallel diagrams in steady-state mode. Besides inductances and reactances of branches, resulting input current, input impedances, consumed power are determined.

Under geometric parameters of arrangement of windings and leg, and connection diagram off windings (or parts of windings) the program makes calculation: matrices of inductive parameters of branches regarding to influence of leg with specified value of magnetic permeability, current of branches and voltages in nodes of branches. In connection diagram of branches the several power sources (current or voltage source), external elements (resistance, inductance, capacity) can be specified.

Calculation of current distribution between parallel parts of winding (groups of coils, wires under the transposition scheme), current distribution in windings made of sheets and busbars, currents in windings of multi-winding transformer at short-circuit as well as in nominal mode can be made in the program.

Calculation results

Calculation results are the tables of currents in branches, input currents and resistances, consumed powers and distributions of voltages in nodes.

The screenshot displays the 'SAPR TON' software interface. The main window shows a table titled 'Ток в катушечных ветвях в режиме СО-ВО1' (Current in coil branches in SO-VO1 mode). The table has the following columns: 'Номер ветви' (Branch number), 'Количество витков' (Number of turns), 'Активное сопротивление, мОм' (Active resistance, mOhm), 'Модуль тока, А' (Current magnitude, A), 'Фаза тока, град.' (Current phase, deg), 'Активная составляющая, А' (Active component, A), and 'Реактивная составляющая, А' (Reactive component, A).

Номер ветви	Количество витков	Активное сопротивление, мОм	Модуль тока, А	Фаза тока, град.	Активная составляющая, А	Реактивная составляющая, А
A1	19	0.844929	24100.81	94.16927	-1752.21	24037.03
A2	33	2.882366	1.17904E-011	-76.44318	2.763781E-012	-1.146189E-011
A3	95.00001	85.25767	1450.263	-86.32261	93.65916	-1457.256
A4	179	160.6434	1450.263	-86.32261	93.65916	-1457.256
A5	14	12.56429	1450.263	-86.32261	93.65916	-1457.256
A6	14	12.56429	2085.99	-76.65581	481.4471	-2029.671
A7	179	160.6434	130.7349	-80.33997	21.93753	-128.8812
A8	95.00001	85.25767	130.7349	-80.33997	21.93753	-128.8812
A9	14	12.56429	130.7349	-80.33997	21.93753	-128.8812
A10	14	12.56429	2085.99	103.3442	-481.4471	2029.671

The left sidebar shows a tree view of calculation options, including 'Электромеханические расчеты' (Electromechanical calculations), 'Расчет токораспределения в обмотках' (Calculation of current distribution in windings), and various other calculation modules like 'Расчет потерь в обмотках' (Calculation of losses in windings) and 'Расчет потерь в баке' (Calculation of losses in tank).



Тип трансформатора : TRMP-9000/10.5-EGYPT
SAPR TON
Номер варианта : 3

Архив | Входные данные и расчет (PRT) | Входные данные (САПР) | Расчеты (САПР) | Результаты (САПР) | Результаты в графическом виде (САПР)

Результаты (САПР)

- Электромеханические расчеты
 - [ТОК] Расчет токораспределения в обмотках
 - Общие входные данные
 - Промежуточные результаты (для контроля)
 - Режимные данные и результаты расчета
 - Режим 1 (CO-BO1+BO2)
 - Режим 2 (CO-BO1)
 - Входные данные
 - Результаты расчета
 - Ток в катушечных ветвях в режиме CO-BO1
 - Входной ток (от каждого источника напряжения) в режиме CO-BO1
 - Распределение напряжения по узлам схемы в режиме CO-BO1
 - Потребляемые мощности (от каждого источника напряжения) в режиме CO-BO1
 - Сопротивление короткого замыкания со стороны источников напряжения в режиме CO-BO1
 - Напряжение короткого замыкания со стороны источников напряжения в режиме CO-BO1**
 - Режим 3 (CO-BO2)
 - Режим 4 (CO-BO1+BO2_3F)
 - Распределение тока в концентраторах
 - [MPO] Расчет магнитного поля в обмотках
 - [P0V] Расчет потерь в обмотках
 - [PRM] Расчет распределения магнитного потока в магнитопроводе
 - [PI0] Расчет потерь и тока холостого хода трансформатора
 - [UKT] Расчет номинальных напряжений и коэффициентов трансформации
 - [RK2] Расчет сопротивлений к.з. пар обмоток
 - [Z0] Расчет сопротивления нулевой последовательности/токораспределения в обмотках
 - [PBT] Расчет потерь в баке
 - [PCT] Расчет потерь в элементах конструкции
 - [OST] Оптимизация схемы трансформации
 - [TRP] Расчет переходных процессов в трансформаторе
- Высовольтные расчеты
- Экономические расчеты
- Тепловые расчеты
- Механические расчеты

Напряжение короткого замыкания со стороны источников напряжения в режиме CO-BO1, %
(приведено к мощности 1.3550 МВА)

Имя источника напряжения	Модуль (Z)	Активная составляющая (R)	Реактивная составляющая (X)
14CO-NOM	0.114447	0.5898114	0.092982

Тип трансформатора : TNCP-17000
SAPR TON
Номер варианта : 4

Соединения ветвей обмоток

- Ветвь C1_1
- Ветвь C2_1
- Ветвь C3_1
- Ветвь C4_1
- Ветвь C5_1
- Ветвь C6_1
- Ветвь C7_1
- Ветвь C8_1
- Ветвь C9_1
- Ветвь C10_1
- Ветвь C11_1
- Ветвь C12_1

Расчетная схема 1 (NAGR_NOM)



MPO

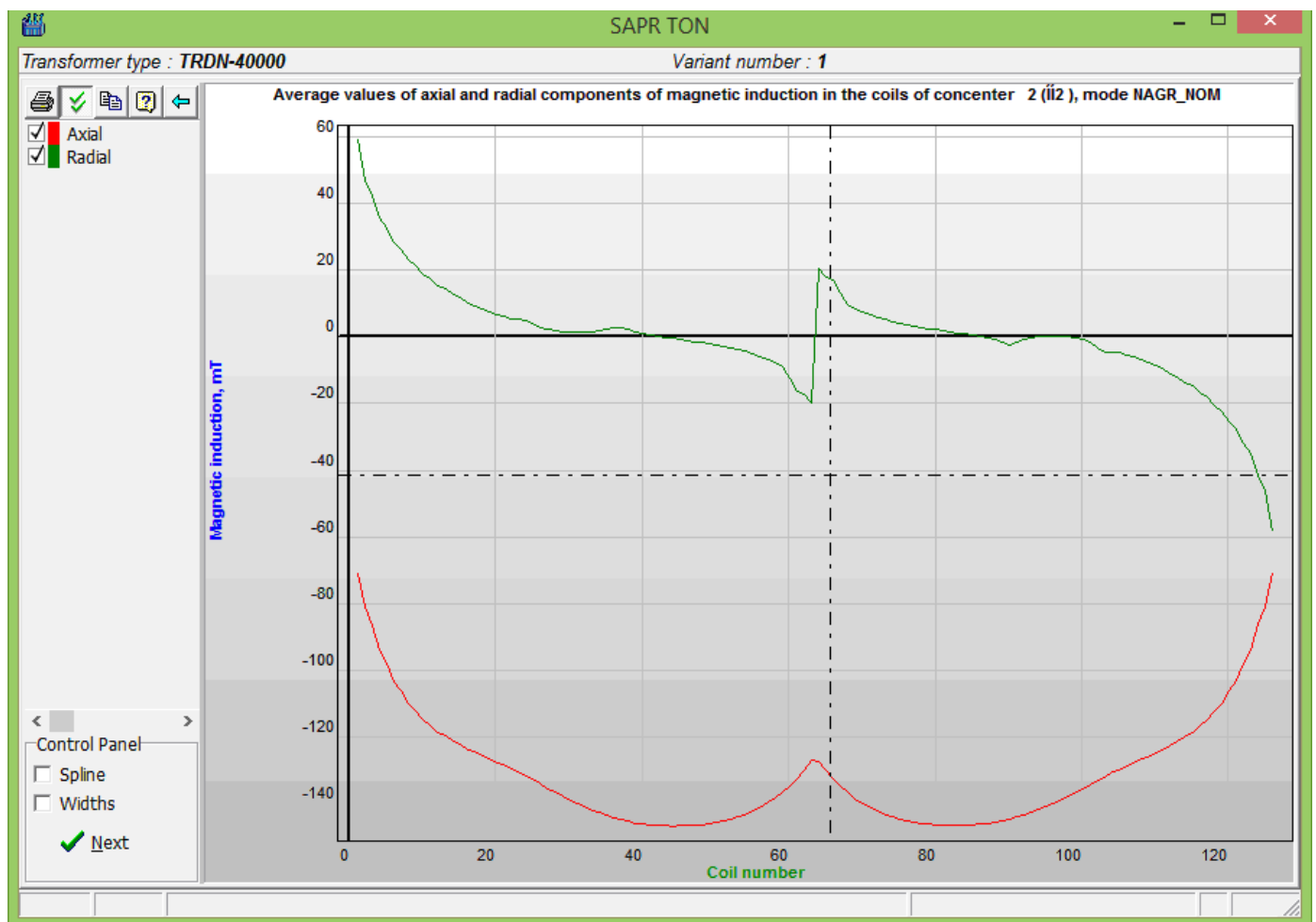
Calculation of magnetic field of windings

Purpose

The program is intended for determination of induction components of magnetic field in coils of power transformer winding coils using axially symmetric closed flat-parallel and open flat-parallel design models of field.

Calculation results

Calculation results are the tables and diagrams of axial and radial induction components of stray field in three generatrices of each coil of each concentre in all specified modes.





POB

Calculation of the main and added losses in windings

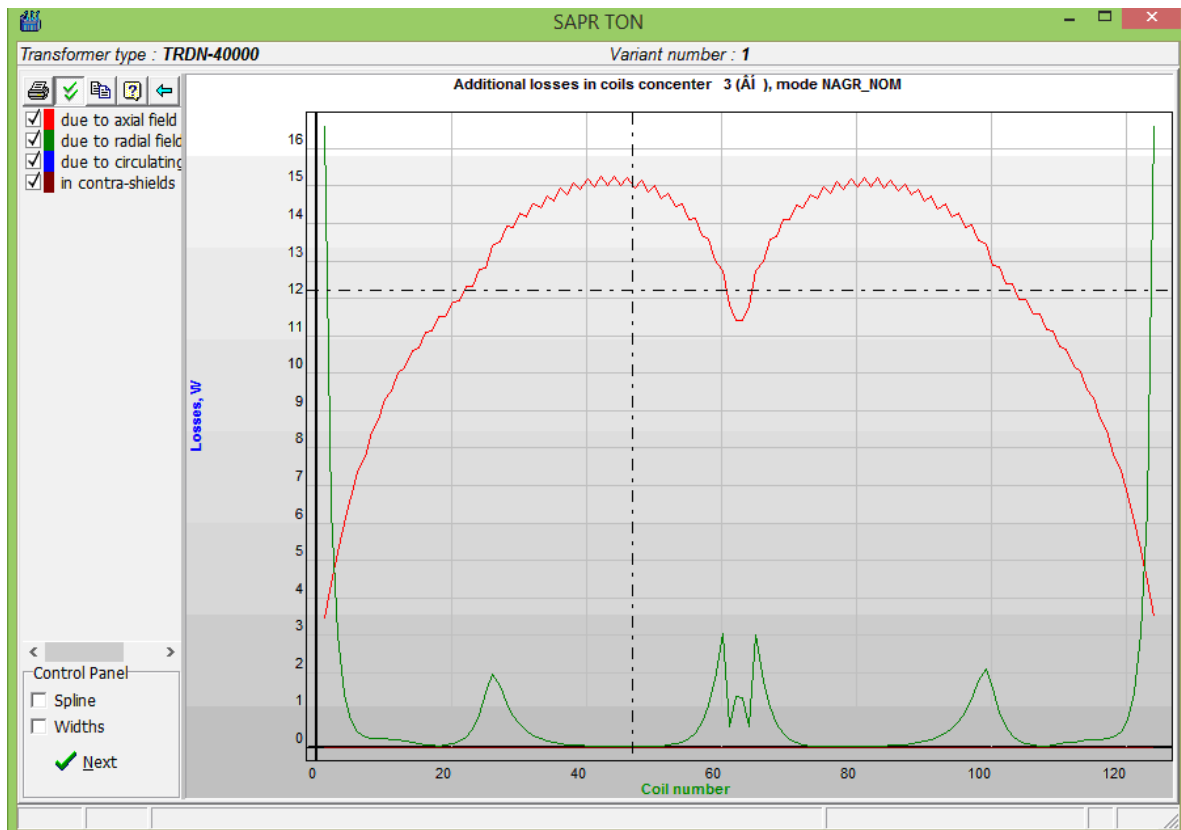
Purpose

The program is intended for determination of the main and added losses in power transformer windings. The program permits:

- calculate the main losses for each mode in each concentre in whole and in its coils;
- calculate added losses from axial and radial components of stray field for each mode in each concentre in whole and in its coils;
- calculate circulating current added losses for each mode in each concentre in whole and in its coils;
- calculate total losses for each mode in each concentre in whole and in its coils;
- calculate total losses in coils and concentres for composite modes which can be used for calculation of losses at out-of-phase or non-sinusoidal currents (with regard of highest harmonics).

Calculation results

Calculation results are the tables and diagrams of distribution of the main and added losses resulting from the longitudinal and transverse components of the field as well as circulating currents and also total losses in concentres and coils in all specified modes.





PRM

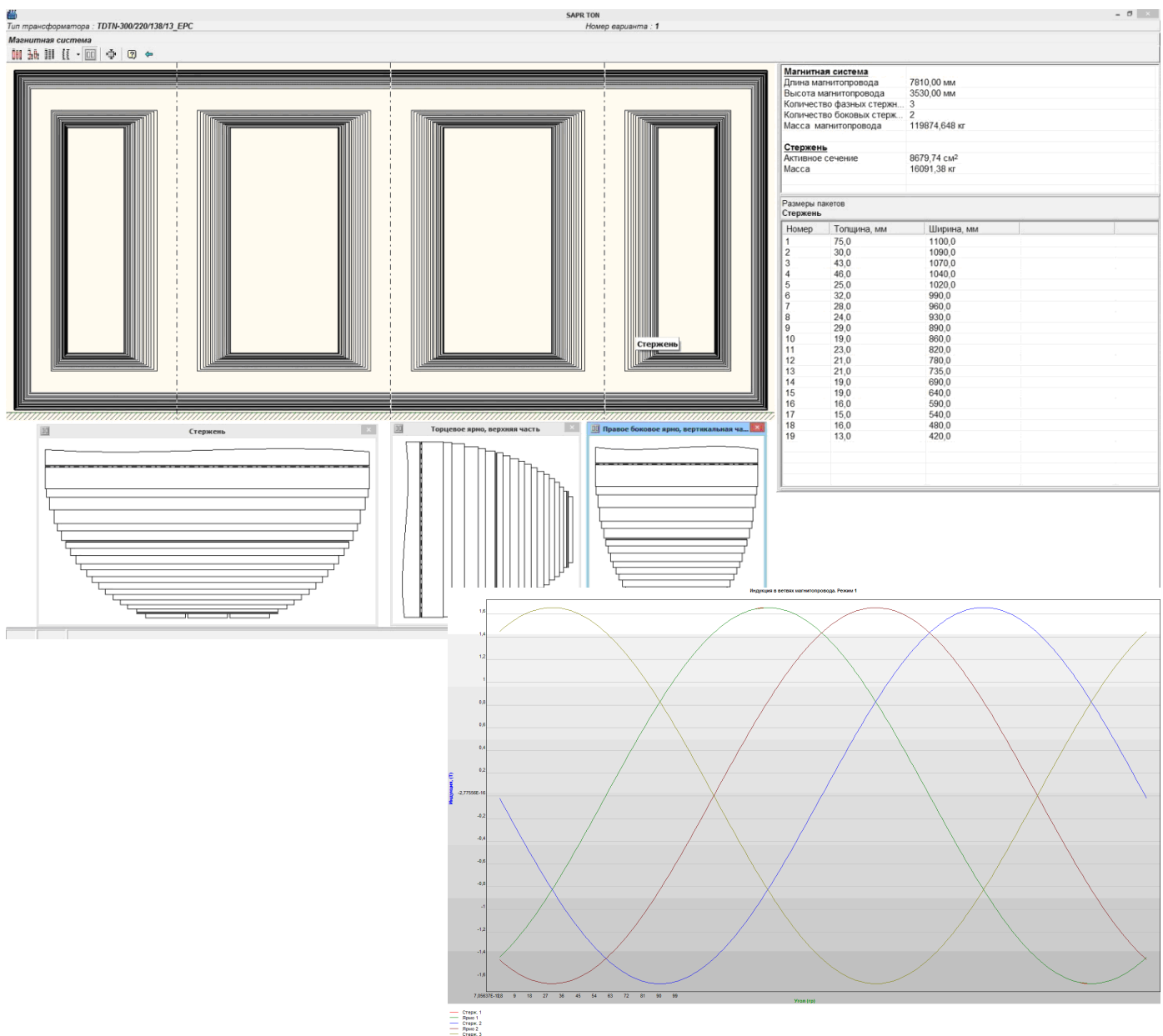
Calculation of distribution of the main magnetic flux

Purpose

The program permits to fulfill the calculation of distribution of the main magnetic flux in magnetic circuit stacks in no-load steady state of transformer. It permits to determine distribution of magnetic flux for transformers with branched magnetic system (three-phase and single-phase ones with side yokes).

Calculation results

Calculation results are the tables of amplitude values of inductions in stacks of the magnetic circuit branches, factor of losses rise resulting from non-sinusoidal shape of fluxes in magnetic circuit branches and diagrams of induction in stacks of magnetic circuit branches. Calculation results are used for determination of losses and no-load current.





PIO

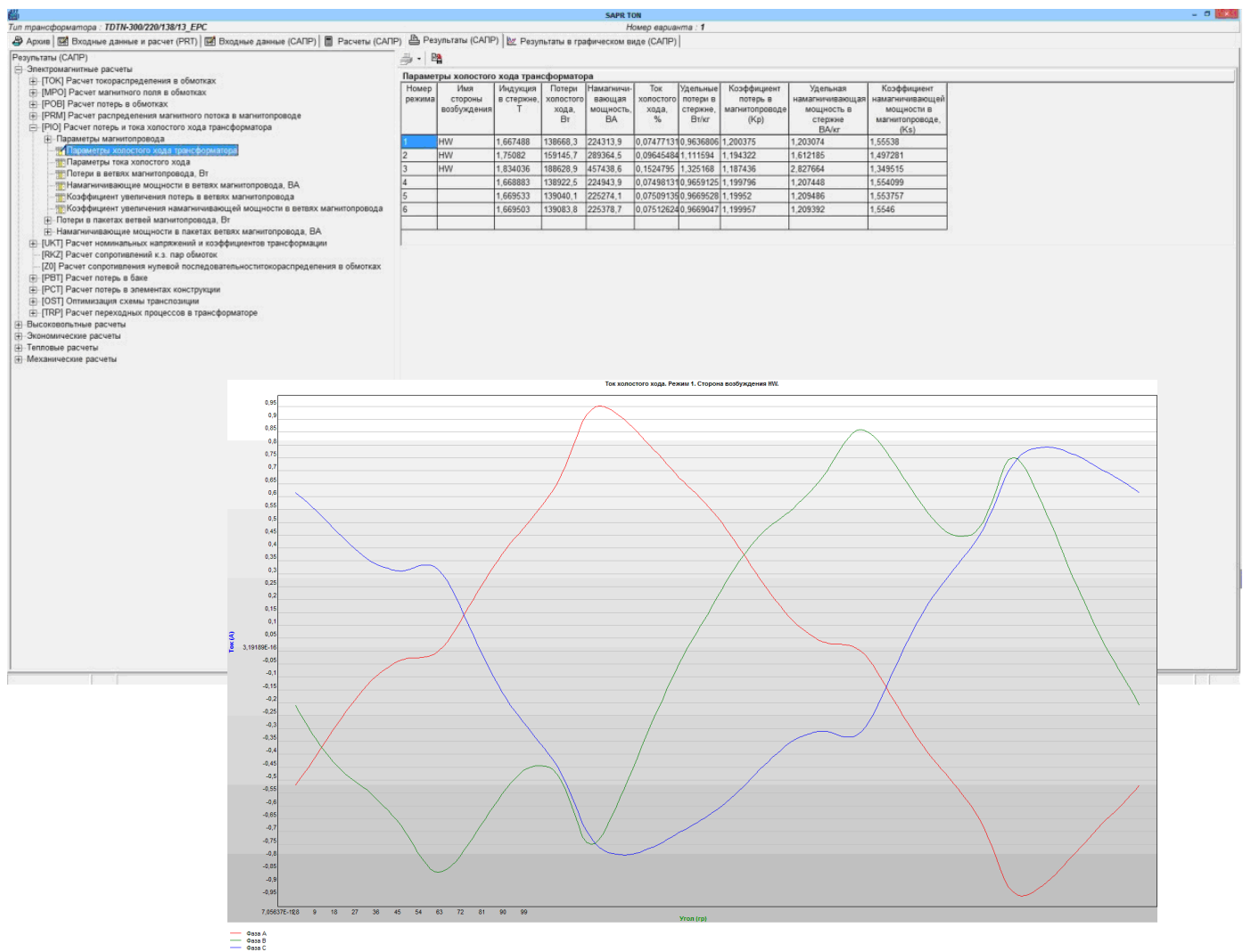
Calculation of losses and no-load current

Purpose

The program permits to calculate masses of magnetic circuit, losses and quadrature exciting watts in magnetic circuit branches, value and shape of magnetizing no-load current of transformer. Program considers steel grade, type and dimensions of magnetic circuit, lamination scheme, distribution of magnetic flux in the main elements of magnetic transformer circuit.

Calculation results

Calculation results are the tables of geometric parameters of magnetic circuit branches, stack masses of magnetic circuit branches, losses and quadrature exciting watts in magnetic circuit branch stacks, no-load current value and diagrams of magnetizing no-load current of transformer.





UKT

Calculation of rated voltages and transformer ratios

Purpose

With specified number of steps, number of turns in regulating steps, nominal numbers of turns and voltages of windings the program calculates phase and line no-load voltages on the secondary windings and transformer ratios for all tap changer positions for all specified pairs of windings. If two tap changers are available in different windings the calculation will be provided.

Calculation results

Tables of rated voltages, transformer ratios, transformer ratio tolerances are the calculation results.



RKZ

Calculation of short-circuit resistance of windings

Purpose

The program calculates short-circuit resistance (inductive component) of transformer (autotransformer) winding pairs with the following assumptions: each winding consists of one or several series connected concentric windings arranged on one or different legs of magnetic circuit.

Within limits of concentric density of ampere-turns is constant. If these assumptions are not fulfilled TOK program should be used for calculation

Calculation results

Short-circuit resistance of winding pairs are the calculation results.



Z0

Calculation of zero-sequence resistance

Purpose

Z0 program is intended for calculation of zero-sequence resistance of three-phase transformers with magnetic system without side yokes having at least one winding with connection diagram Yn or Zn.

Calculation results

For three-phase transformers with 3/0 magnetic system if ferromagnetic shunts on the tank wall are available or absent, two values of zero-sequence resistance will be calculated.

- Load current zero-sequence resistance (with regard to ferromagnetic shunts (in this case the tank is considered absent)).
- Short-circuit current zero-sequence resistance without ferromagnetic shunts (in this case demagnetizing influence of tank is considered).



PBT

Calculation of losses in tank

Purpose and capabilities of the program

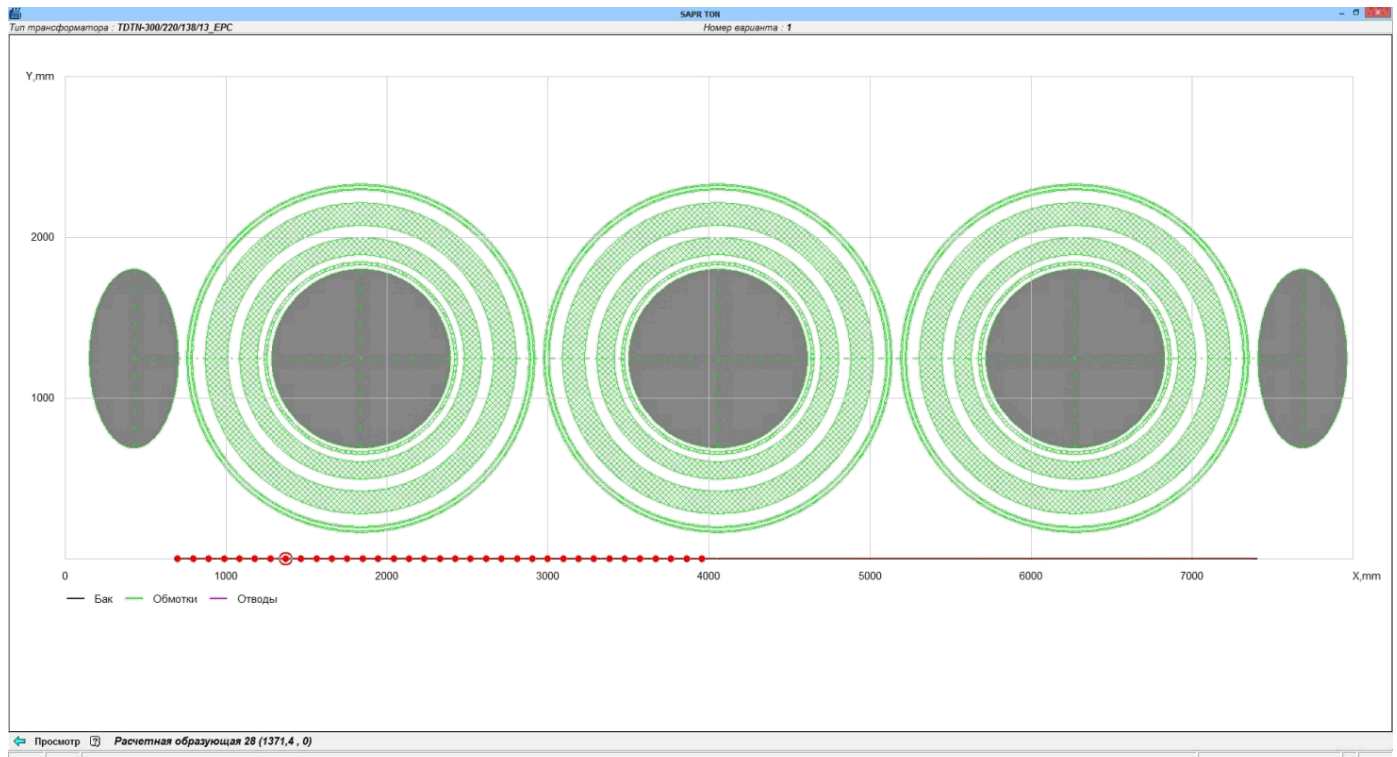
By means of superposition of axisymmetric of magnetic fields of all legs with windings and multi-ampere leads the magnetic field on the tank wall is calculated. For each space harmonic of field the tank influence coefficient considering the surface resistance of the tank wall is available. With value of field tangential component specific surface losses are calculated on the tank. Summing up of these losses provides the total losses in the tank. Influence of shunts is considered with empirical method.

Besides the program calculates rise of tank wall temperature over oil temperature and distribution of temperature on the tank wall.

Calculation result

For each mode the total losses in the tank and also tables and diagrams of distribution are derived:

- root-mean-square inductions on the tank surface;
- relative distribution of normal and tangential components of field in points of mesh on the tank surface.
- distributions of the tank wall temperature rise over oil temperature.





PCT

Calculation of total added losses in structural elements

Purpose

Calculation of total losses is made for two-winding transformers with one and two concentric HV winding and also for three-winding transformers and autotransformers in two winding mode. For each load mode the total losses in structural elements are determined according to empirical formulae based on factors obtained experimentally.

Calculation results

Table "Total added losses on modes" is the results of calculation.



TRP

Calculation of transient processes

Purpose

The program is intended for simulation of transient modes of operation of single-phase and three-phase transformers and three-phase groups of single phase transformers with random connection diagram of transformer windings and with arbitrary connection of the transformer external terminals to supplying voltage sources and loads. The program can be used for determination of:

- transformer inrush current with random energizing and de-energizing of single-phase and three-phase voltage sources;
- transient modes related to switching on/off of different types of loads in particular short-circuit, capacitor banks etc.;
- steady state modes with connection of different types of loads.

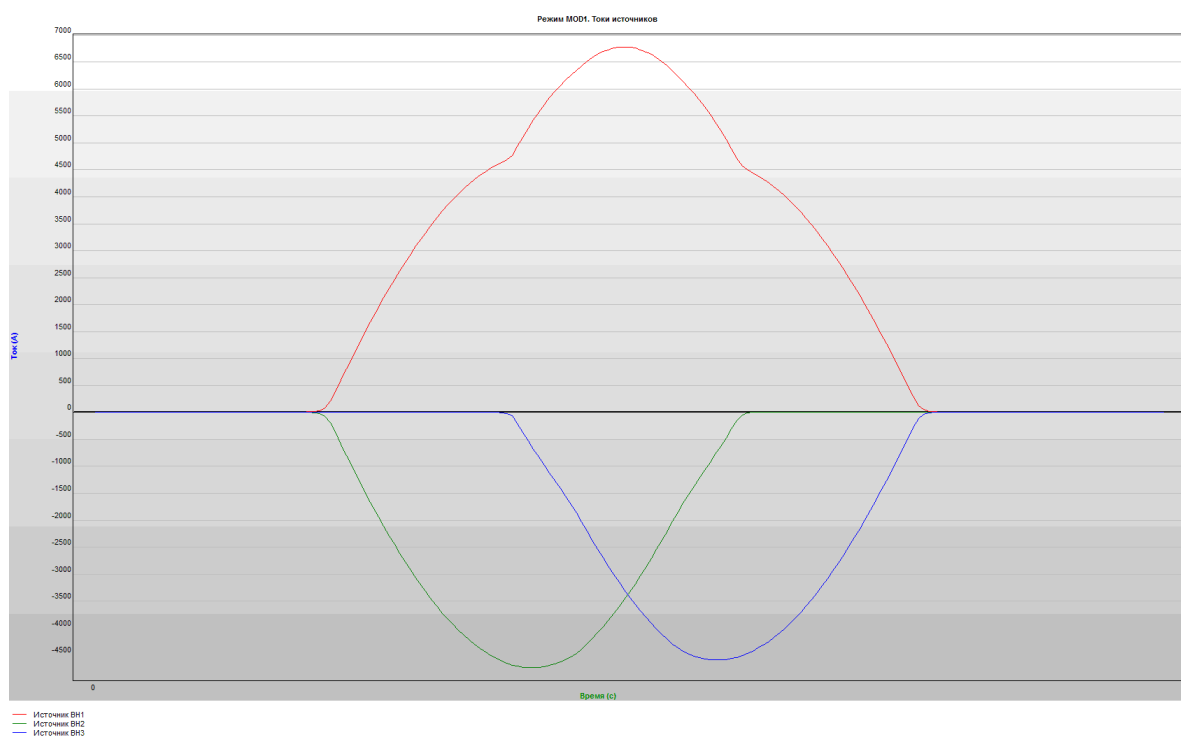
The program provides two main modes of calculation:

- steady state mode when calculation starts with steady periodic values of currents and voltages in all branches of circuit.
- energizing mode when calculation starts with switching on of voltage sources. In this case the calculation initial conditions can be both zero and specified by the user in form of values of residual inductions in legs of magnetic circuit, voltages on the capacitor bank etc.

In all modes during calculation switching of voltage sources and loads can occur. It determines variety of calculations of transient modes of transformer.

Calculation results

Calculation results are the diagrams of voltage and current sources, external load branches, electric branches of transformer and inductions of magnetic circuit branches.



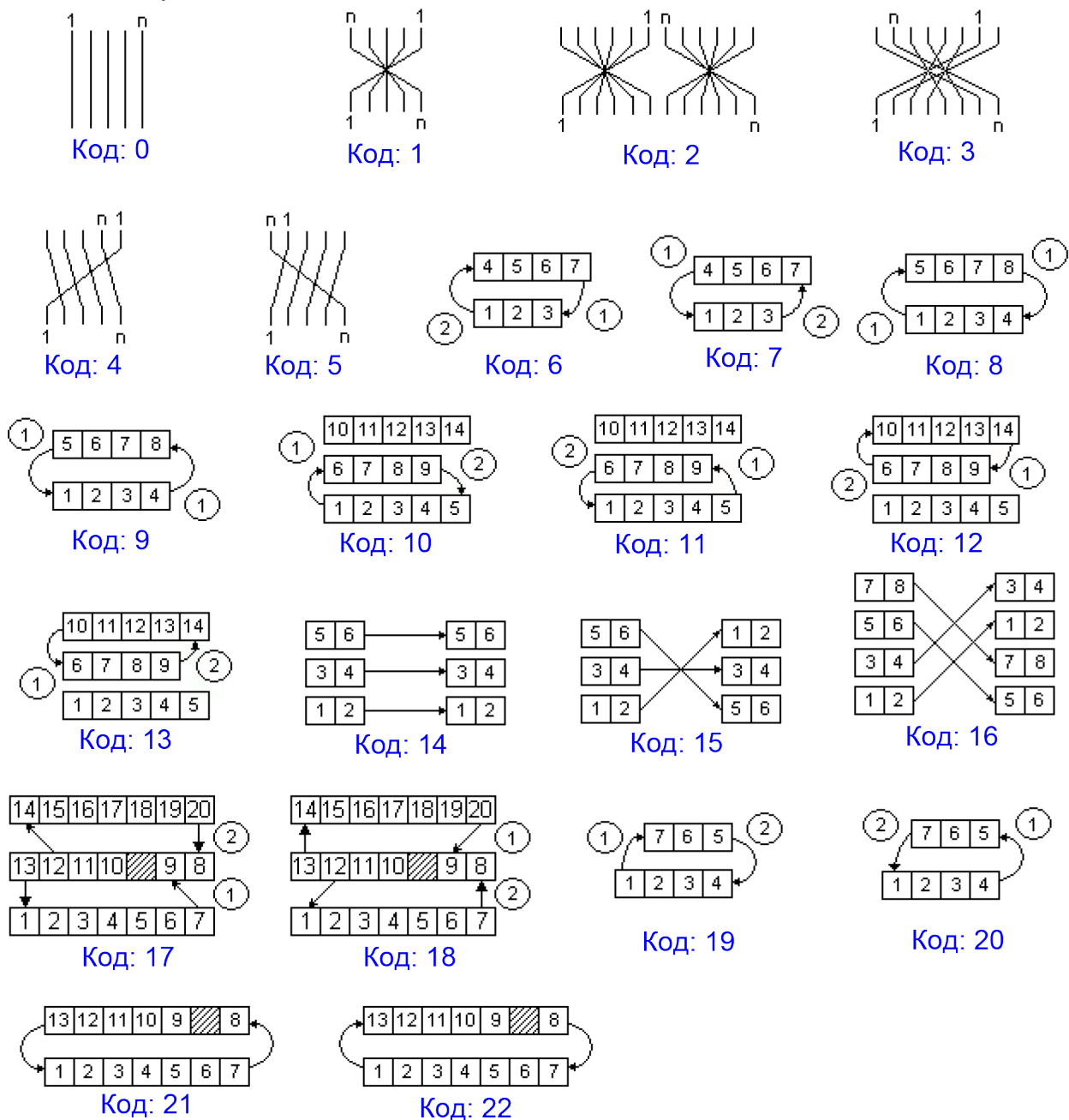


OST

Optimization of transposition scheme

Purpose

OST program is intended for selection of optimal locations of the wire transpositions in helical windings of transformers, autotransformers and reactors with specified scheme of transposition. Optimal solution is determined by means of minimizing of values of circulating current losses. Optimization is made for such codes of transposition schemes:



Calculation results are:

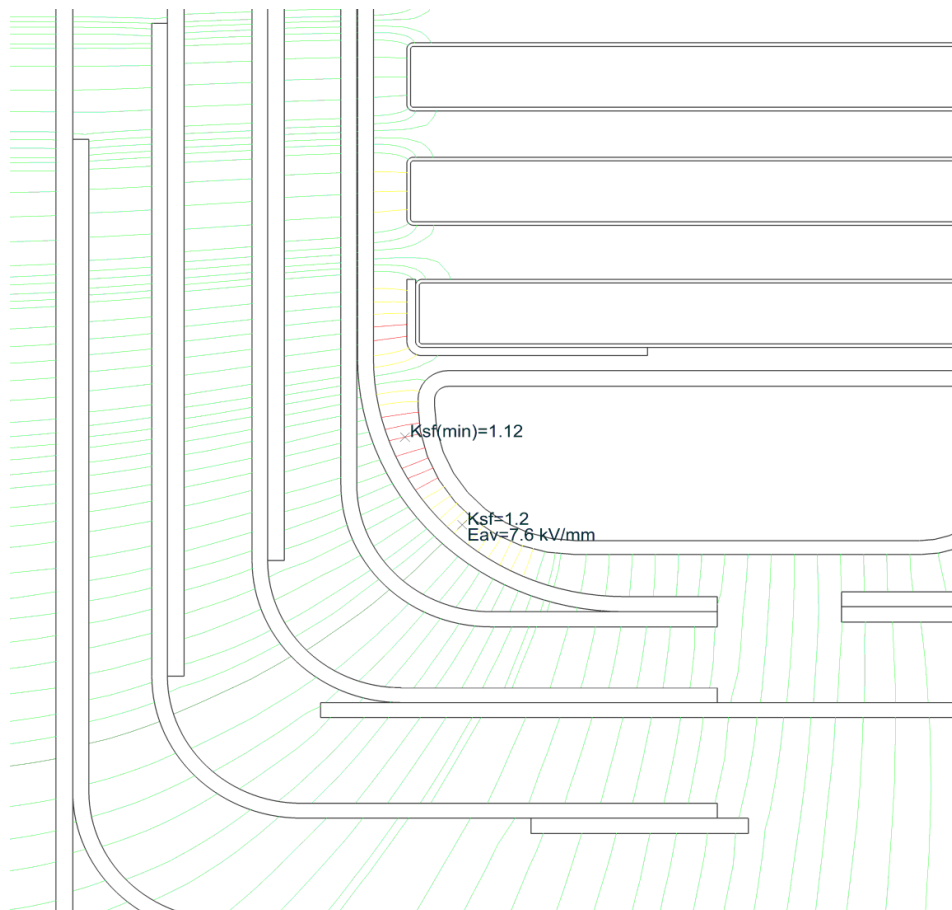
- losses in design helical winding resulting from circulating currents before and after optimization, W ;
- currents and losses in each wire of helical winding before and after optimization;
- optimal arrangement of transpositions.



EPC

Purpose

EPC program product is used for calculation and design of the main insulation of 110–1150 kV transformers. Calculation is made by finite element method. Using together with strength data bases Endins, Endins2, Midins it permits to form two-dimensional (2-D) planar or axisymmetrical models for calculation of electric field of problem are of transformer insulation and estimate probability of breakdown.



Calculation results

Results of calculation are:

- distribution of electric potentials;
- distributions of electric field strength;
- plotting of equipotential lines;
- plotting of force lines;
- calculation of safety factors in insulating medium (if Endins, Endins2, Midins are connected, transformer oil rises over the medium). Safety factors are calculated for full lightning, switching, one-minute and one-hour types of tests;
- calculation of electric field strength: in point of the maximum and medium value along force line;
- calculation of the maximum and tangential component of electric field strength on the insulation element surface or along path specified by the user;
- localization of the minimum safety factor.



TCM

Thermal calculation of cooling system

Purpose

The program permits to make calculation of average temperature of oil in the tank, temperature of the top oil and excess of these temperatures over the temperature of cooling medium for specified types and quantity of radiators, specified types and quantity of fans, specified flow rate of oil per one radiator (cooler). If parameters and quantity of radiators, fans, coolers, oil flow rate are not specified these parameters are determined automatically depending on type of cooling system and utmost values of oil and winding temperatures.

Calculation is made for multi-step radiator type cooling systems and cooling systems with coolers:

- ONAN – radiators,
- ONAF – radiators + fans,
- OFAF – coolers or radiators + fans + pumps,
- OFWF – water coolers,
- ODAF – coolers or radiators + fans + pumps,
- ODWF – water coolers,
- ODAN – radiators + pumps,
- ONAN/ONAF – radiators + fans,
- ONAN/OFAF – radiators + fans + pumps,
- ONAN/ONAF/ONAF – radiators + fans,
- ONAN/ONAF/OFAF – radiators + fans + pumps,
- ONAN/ODAN – radiators + pumps,
- ONAN/ODAF – radiators + fans + pumps,
- ONAN/ONAF/ODAF – radiators + fans + pumps,
- ONAN/ODAN/ODAF – radiators + fans + pumps.

Calculation results

Calculation results are average temperature of oil in the tank and temperature of top oil in the tank, quantity and arrangement of radiators and fans, quantity radiator panels, quantity of coolers, flow rate for OD, OF systems.



TCO

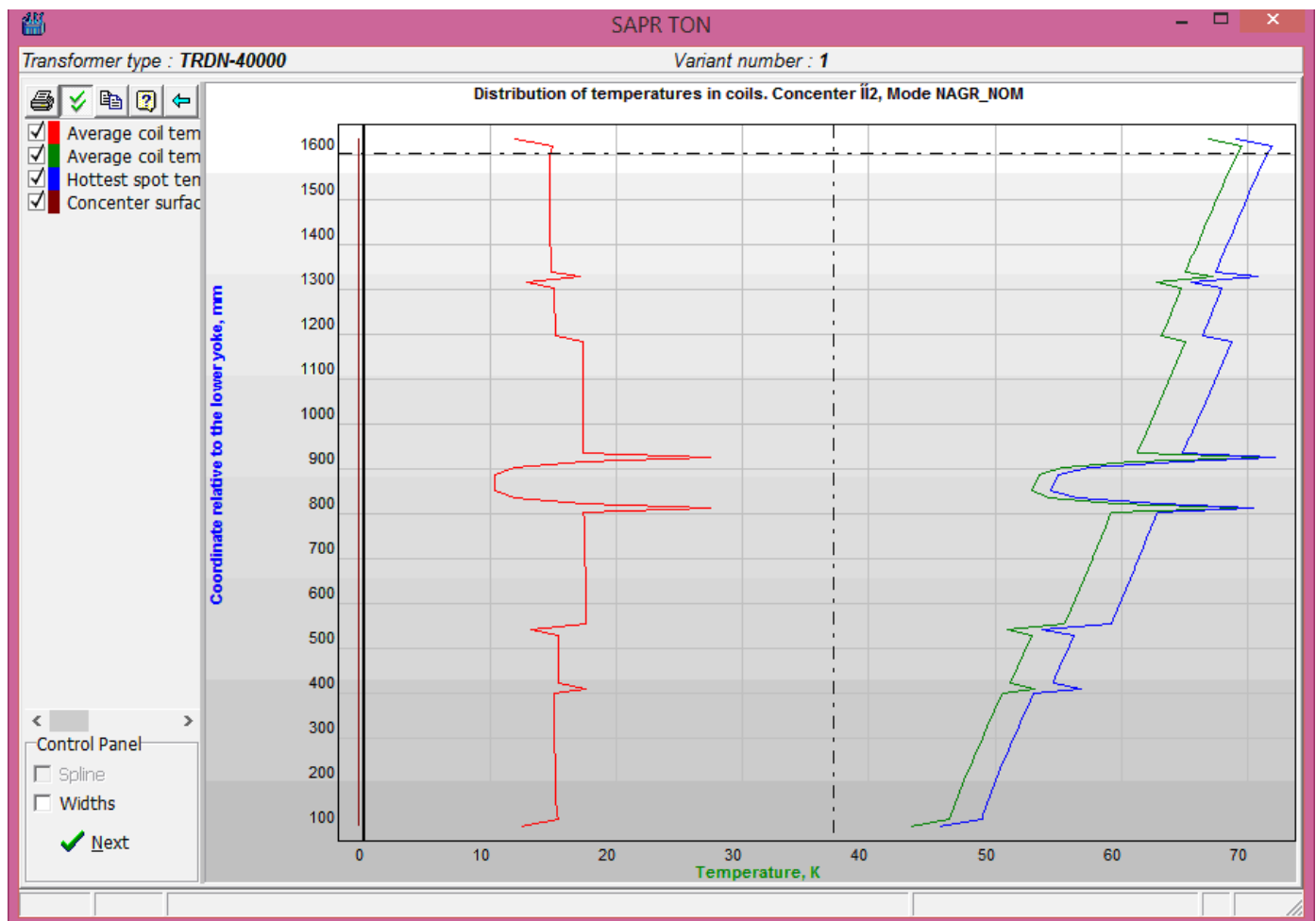
Thermal calculation of windings

Purpose

The program permits to calculate density of thermal flux of concentric coils, average rise of temperatures of coils over surrounding oil, the average rise of temperatures of windings over the average temperature of oil, location and temperature of the hot spot of the winding. The calculation is made for ONAN, ONAF, OFAF OFWF cooling systems and cooling systems with directed oil circulation in axial cooling ducts of concentrics (ODAF and ODWF). Concentrics can be coil-type, helical and multi-layer cylindrical and made of copper rectangular wires.

Calculation results

Calculation results are the tables of average temperatures of the most heated concentric, number and average temperature of the most heated coil, temperature of the hot spot in the concentric for each calculation mode.





TRM

Calculation result of magnetic circuit

Purpose

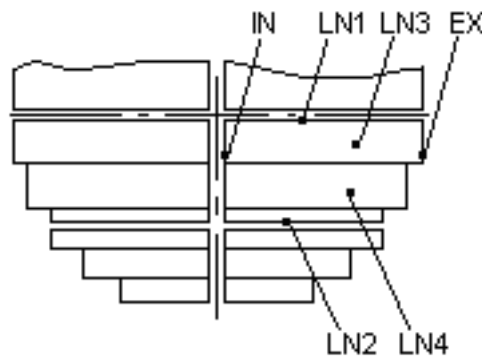
The program permits to calculate rise of temperature of hot spots of the leg stacks, distribution of temperatures in leg section on groups of stacks, rise of top oil temperatures in the leg ducts.

Calculation results

Calculation results are: temperatures of top oil in cooling ducts, rise of temperature of the leg surface over temperature of cooling medium for all groups of stacks divided by cooling ducts, temperatures of hot spots inside the stacks.

Explanation:

Position of spot in the stack section.



- EX – on external end side.
- IN – on internal end side.
- LN1 – on the side nearest to longitudinal axis. This side is adjacent to longitudinal duct between stacks.
- LN2 – on the side far from longitudinal axis. This side is adjacent to longitudinal duct between stacks.
- LN3 – on the side nearest to longitudinal axis. This side is adjacent to longitudinal duct inside the stack.



TEO

Thermal calculation of leads

Purpose

The program permits to calculate rise of average temperatures of leads over the temperature of oil and cooling medium.

Type of design covered by programs

Calculation is made for ONAN, ONAF, OFAF, OFWF, ODAF, ODWF cooling systems for the following types of areas of leads:

- areas of leads consisting of rectangular insulated conductors;
- areas of leads with rectangular section;
- areas of leads with round section;
- areas of leads made of open pipe;
- areas of internal leads consisting of rectangular insulated conductors;
- areas of internal leads with rectangular section.

Leads can be with constant and different insulation thickness.

Calculation results

Calculation results are rise of average temperatures of leads over temperature of oil and cooling medium.



PGR

Calculation of allowable systematic loads and emergency overloads of windings

Purpose

PGR program is intended for calculation of allowable systematic loads and emergency overloads of oil transformer windings with thermal wear of insulation under Montsinger's criterion. Calculation is made under IEC 60076-7:2005 Power transformers – Part 7: Loading Guide for oil-immersed power transformers. Program permits to determine the following parameters of two-step diagrams of loading for all specified nominal loading modes of transformer:

- Values of multiplication factors of K2 systematic overloadings for specified combinations of multiplication factors of K1 initial loading and duration of overloading in calculated range of cooling medium which are permissible under conditions of normal thermal insulation wear and temperature limits of top oil and winding hot spots.
- Relative daily thermal wear of winding insulation, rise of top oil temperature and winding hot spot over the temperature of cooling medium, temperature of cooling medium which is the maximum permissible under values of temperatures of top oil and winding hot spots for all specified two-step diagrams of emergency overloads at specified ambient temperature.
- In mode of online monitoring the top oil temperature, hot spot temperature and insulation wear for temperature of cooling medium and loading value continuously changing in time are calculated. Also it can be used for calculation of step-by-step loading diagrams.

Design range for measurement of parameters is specified by user or taken by default.

The following values are taken by default:

- Complete calculation of permissible systematic and emergency overloads is made in case of such multiplication factors of initial loads K1: 0.25; 0.4; 0.5 ; 0.6; 0.7; 0.8; 0.9; 1.0 and overload time K2: 0.5; 1; 2; 4; 6; 8; 12; 24 h.
- Complete calculation of emergency overloads will be made when permissible multiplication factors of overloads K2 is 1-2 with step of 0.1.
- Temperature of cooling medium is from -20 to $+40^{\circ}\text{C}$.

Calculation results

Calculation results are permissible multiplication factor and duration of K2 overloads, top oil temperature and hot spot of the windings, wear of insulation and thermal time constant of transformer for specified modes and load diagrams. For each table of the calculation results the graphic HELP is available.



VOZ

Calculation of height and lamination clearance of windings

Purpose

The program calculates shrinkage of transformerboard spacers and paper insulation of windings at all stages of technological treatment. Required height of spacer column in the initial condition providing the specified axial dimension of winding in complete transformer is determined. Lamination clearance "upper yoke – pressing ring" is determined during the transformer assembly.

The calculation is made by iteration method using experimental mechanic characteristics of two grades of transformerboard (ordinary one is with density of less than 1.15 g/cm³ and reinforced one with density of 1.25 g/cm³) and two grades of paper (ordinary and reinforced ones). During calculation non-uniformity of pressing of coil-to-coil spacers on thickness is considered.

The program is to be used for transformers windings of which are subject to preliminary thermal vacuum treatment in pressed condition.

Calculation results

Calculation results are height of the spacer column in initial condition and lamination clearance "upper yoke-pressing ring" during transformer assembly.



SND

Calculation of sound pressure and sound power level

Purpose

The program is intended for calculation of transformer sound level. The program is used for making the calculation part of design of general-purpose transformers operating at frequency of 50 (60) Hz.

Calculation of sound level of transformers covers:

1) general-purpose single-phase power transformers:

- with flat laminated magnetic system consisting from one leg and two side yokes;
- with flat laminated magnetic system consisting of two legs and two side yokes with compensation winding on the one of side yokes;
- with flat laminated magnetic system consisting of two legs without side yokes;

2) general-purpose three-phase power transformers:

- with leg-type flat laminated magnetic system;
- with five-leg type flat laminated magnetic system.

Possibility of calculation of transformers with different cooling systems is considered. The calculation is made within range of rated induction in leg of 1.2 – 1.8 T.

Calculation results

Calculation result: level of sound pressure and sound power at the distance of 0.3 and 2 m from the sound source.

