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COMPARATIVE ANALYSIS OF MATERIAL CONSUMPTION OF PLANAR AND SPATIAL ELECTROMAGNETIC SYSTEMS

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Розглянуто особливості планових і об'ємних трансформаторів, будову, залежність середніх довжин обмоток від геометричних співвідношень активної частини.

Ключові слова: *плоский трансформатор, просторовий трансформатор, зниження матеріаломісткості.*

Features of planar and volumetric transformers, structure, dependence of average lengths of windings on the geometric relationships of the active part are considered.

Keywords: *planar transformer, spatial transformer, reduction of material consumption.*

The substantiation of achieving the technical effect of reducing the mass and material consumption of a small and medium power three-phase transformer is possible by using symmetrical twisted spatial magnetic conductors with parallel walls of winding windows. This can be done through a comparative analysis between a classical flat transformer with parallel walls of winding windows and the configuration of the winding coil of the active part with a hexagonal inner contour of the yoke and a winding wire diameter of dэл < 0.85 mm and dэл> 0.85 mm, in compliance with the principle of electromagnetic equivalence [1, 2, 3]. The comparative analysis is based on a comparison of the volumes of magnetic conductors and the average lengths of turns of windings.

Table 1 shows that the volume of an electrical steel transformer with a twisted spatial magnetic circuit in the real range of the coefficient of change $\gamma 0=1\ldots5$ on 25… is 40% less than the volume of steel of the planar transformer.

Table 1.

Dependences of volumes of magnetic conductors electromagnetically equivalent planar and spatial transformers from the coefficients geometry of the winding window and the rod

λ_{o}	$V_{пл} \cdot 10^6$, m^3			$V_{пр} \cdot 10^6$, m^3		
	λ_c=1,0	λ_c=1,5	λ_c=2,0	λ_{cc}=1,0	λ_{cc}=1,5	λ_{cc}=2,0
0,5	836,83	789,33	761,02	414,37	431,17	445,33
1,0	779,00	731,51	703,19	426,36	443,15	457,31
1,5	774,56	727,06	698,75	452,84	469,64	483,79
2,0	784,28	736,79	708,47	481,00	497,79	511,95
2,5	799,31	751,81	723,50	508,61	525,40	539,56
3,0	816,57	769,07	740,76	535,16	551,95	566,11
3,5	834,78	787,28	758,97	560,58	577,38	591,53
4,0	853,31	805,82	777,50	584,94	601,73	615,89
4,5	871,86	824,36	796,05	608,30	625,09	639,25
5	890,25	842,75	814,44	630,77	647,56	661,72

We can conclude that at different values of the coefficient $\lambda_{o} = 2{,}5 \ldots 5$ the average length of the coil of the transformer of the classical flat design l_{WK} on 3 ... 6% more than the average lengths of turns $l_{W}^{'}$ and $l_{W}^{''}$ coils of the spatial transformer.

Estimated dependences of the change in the average length of the turn for the above тра transfor $l'_{w}, м$ 1 KVA are presented in tables 2 and 3 for two configurations of winding coils.

Table 2.

Dependences of average coil lengths for electromagnetically equivalent planar and spatial transformers

λ_{o}	$l_{WK} \cdot 10^2$, m			$l_{W}^{'} \cdot 10^2$, m		
	λ_c=1,0	λ_c=1,5	λ_c=2,0	λ_{cc}=1,0	λ_{cc}=1,5	λ_{cc}=2,0
1,0	25,80	26,09	26,65	23,88	24,11	24,63
1,5	24,06	24,35	24,91	22,144	22,37	22,89
2,0	23,02	23,31	23,87	21,11	21,33	21,85
2,5	22,31	22,60	23,17	20,40	20,62	21,14
3,0	21,79	22,08	22,64	19,88	20,10	20,62
3,5	21,38	21,67	22,24	19,47	19,69	20,21
4,0	21,06	21,35	21,91	19,14	19,36	19,88
4,5	20,79	21,08	21,64	18,87	19,09	19,61
5	20,56	20,85	21,41	18,64	18,86	19,383

Table 3.

Dependences of average coil lengths for electromagnetically equivalent planar and spatial transformers

λ_o	$l_{WK} \cdot 10^2$, m			$l''_W \cdot 10^2$, m		
	λ_c=1,0	λ_c=1,5	λ_c=2,0	λ_{cc}=1,0	λ_{cc}=1,5	λ_{cc}=2,0
1,0	25,80	26,09	26,65	23,88	24,11	24,63
1,5	24,06	24,35	24,91	22,14	22,37	22,89
2,0	23,02	23,31	23,87	21,12	21,33	21,85
2,5	22,31	22,60	23,17	20,40	20,62	21,14
3,0	21,80	22,08	22,64	19,88	20,10	20,62
3,5	21,38	21,76	22,24	19,47	19,69	20,21
4,0	21,06	21,35	21,91	19,14	19,36	19,88
4,5	20,79	21,08	21,64	18,87	10,09	19,61
5	20,56	20,85	21,41	18,64	18,86	19,38

Thus, the configuration of the active part of the transformer with a twisted spatial magnetic circuit in addition to reducing the cost of steel provides a reduction in the cost of copper, ie satisfies modern requirements for resource conservation.

Conclusions:

1. At different values of the coefficient between 2.5 and 5, the average coil length of the transformer coil of the classical flat design is 3% to 6% longer than the average coil lengths and coils of the spatial transformer.

2. The configuration of the active part of the transformer with a twisted spatial magnetic circuit not only reduces the cost of steel but also the cost of copper, meeting modern requirements for resource conservation.

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