4LP6-04

SYSTEM APPROACH OF USABILITY OF HTS ELECTRICAL MACHINES IN FUTURE ELECTRIC AIRCRAFT

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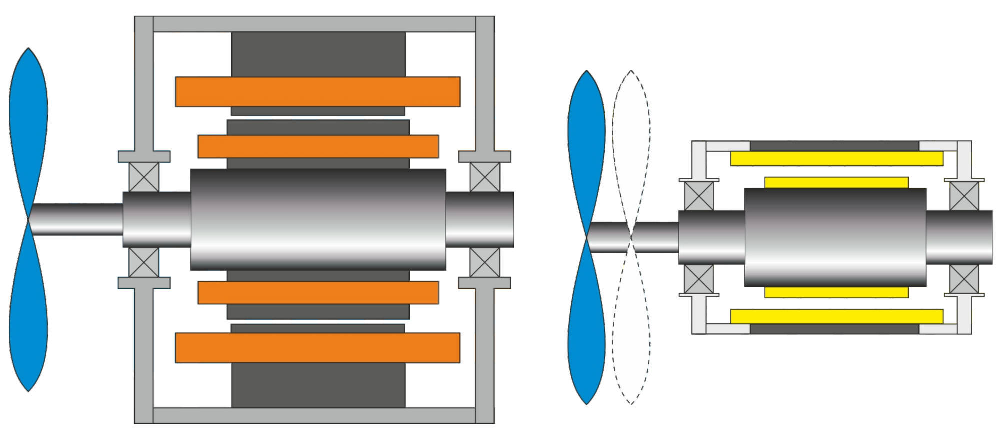
The concept of the more electric aircraft and fully electric aircraft implies development of fully new energy system. The main parts of such system will be electric motors and generators which should possesses extremely high specific power (up to 20 kW/kg). Whereas for conventional electrical machines could possess only 4 kW/kg, because of the ferromagnetic core and copper windings. The increasing of the specific power of electric machine is possible with application of HTS 2G windings. The most promising is ironless fully HTS machine.

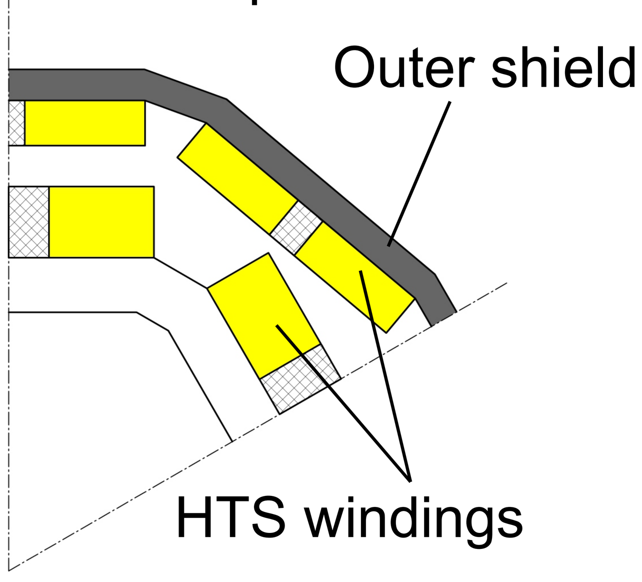
Conventional motor Fully HTS motor



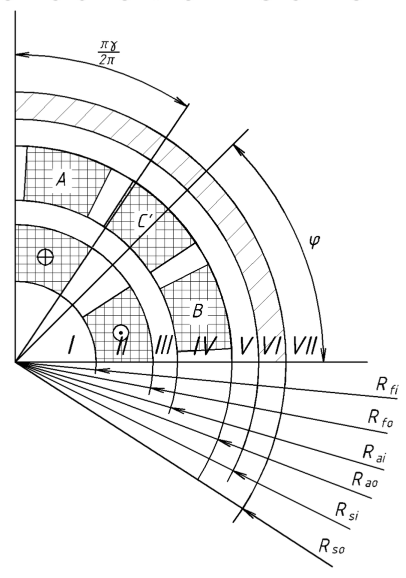
- Application of racetrack HTS coils for field and armature windings
- Low lossesdue to application of HTS rotor and stator windings and low volume of ferromagnetic parts
- Oly one ferromagnetic part - outer magnetic shield

Fully HTS ironless machine

Principal scheme



Calculation scheme



Main parameters

EMF:

$$E_0 = 16 f \mu_0 w_f W_a L_S K_f K_a I_{sp\_f} \cdot \left(R_1 R_2 (2+p) p\right)^{-1} \cdot \left(R_3 R_4 / (2-p) + R_5 K_{\mu i} R_3 R_7 \left(R_{si}^{2p} R_6 (2+p)\right)^{-1} \right)$$

Inductive Resistance:

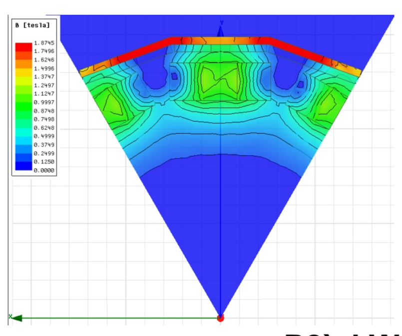
$$X_a = 4 f m W_a^2 K_a^2 L_s \mu_0 \cdot$$

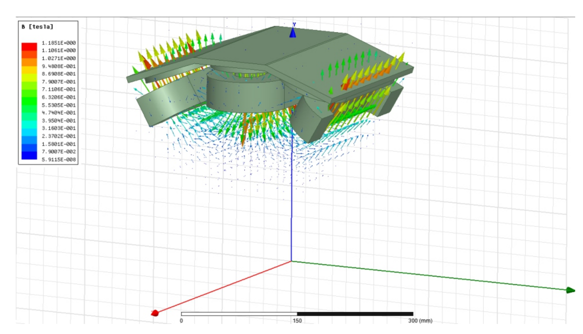
$$\left(p\left[1 - (R_{ai}/R_{ao})^2\right]^2 (p+2) \right)^{-1} \left(1 - (p+2)(p-2)^{-1} (R_{ai}/R_{ao})^4 + \right.$$

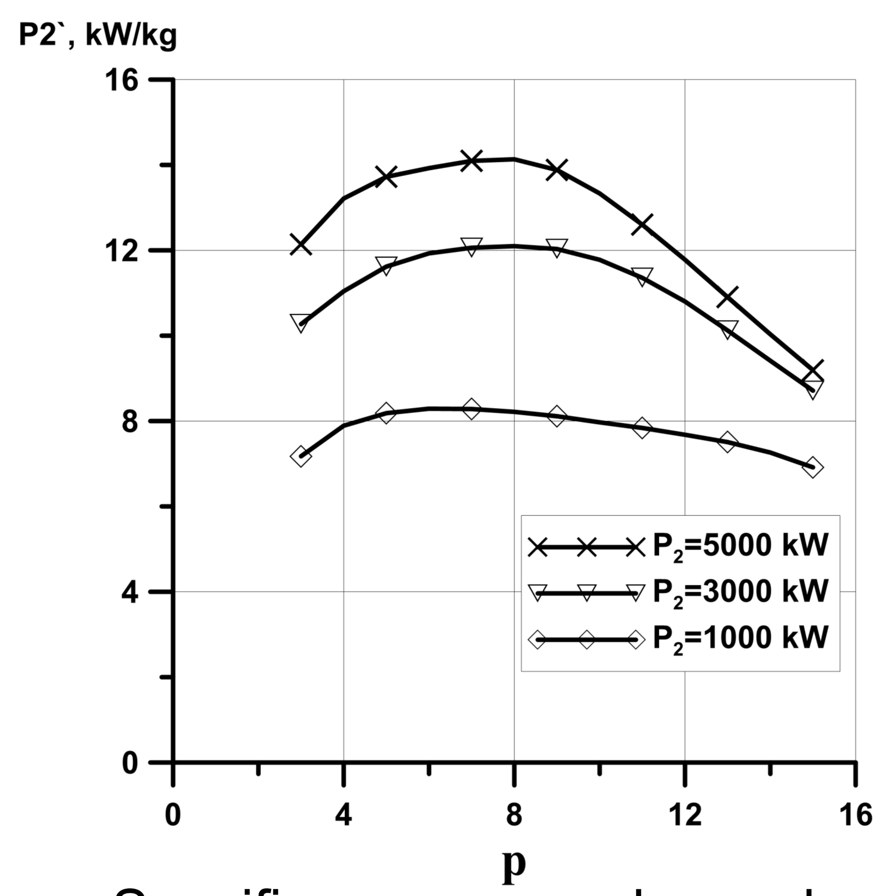
$$\left. + 4(p-2)^{-1} (R_{ai}/R_{ao})^{p+2} + 2 R_5 K_\mu R_7^2 \left(R_6 (p+2) R_{si}^{2p} R_{ao}^4 \right)^{-1} \right)$$

Results of analysis of fully HTS machine specific power including cooling system

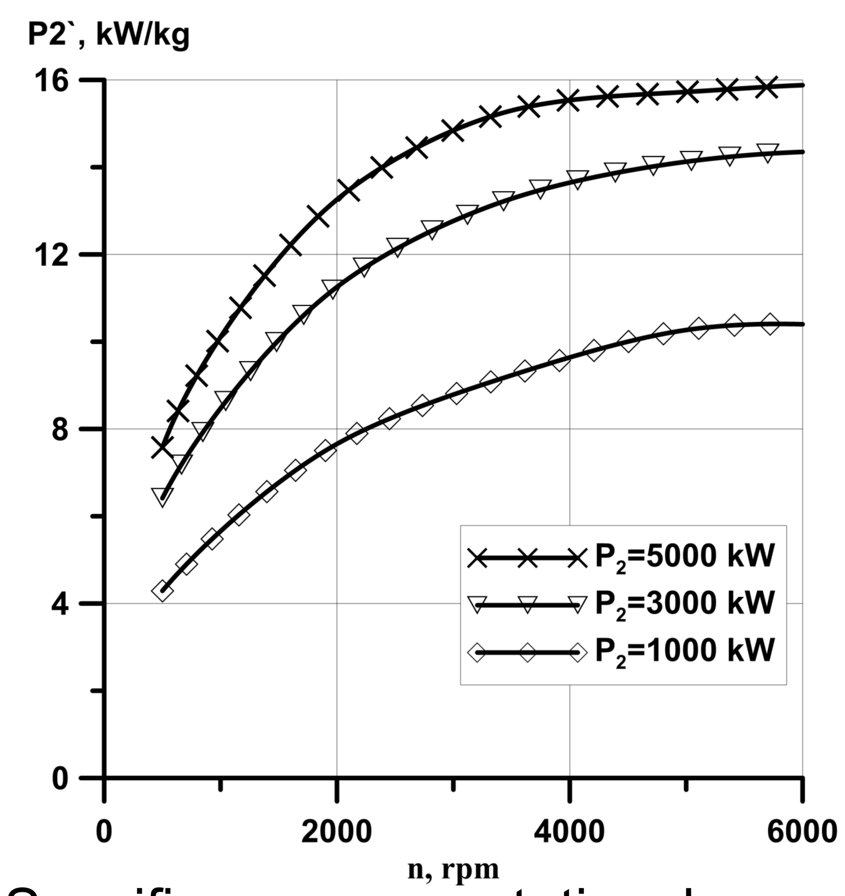
Analytical methodology — Optimization — FEM



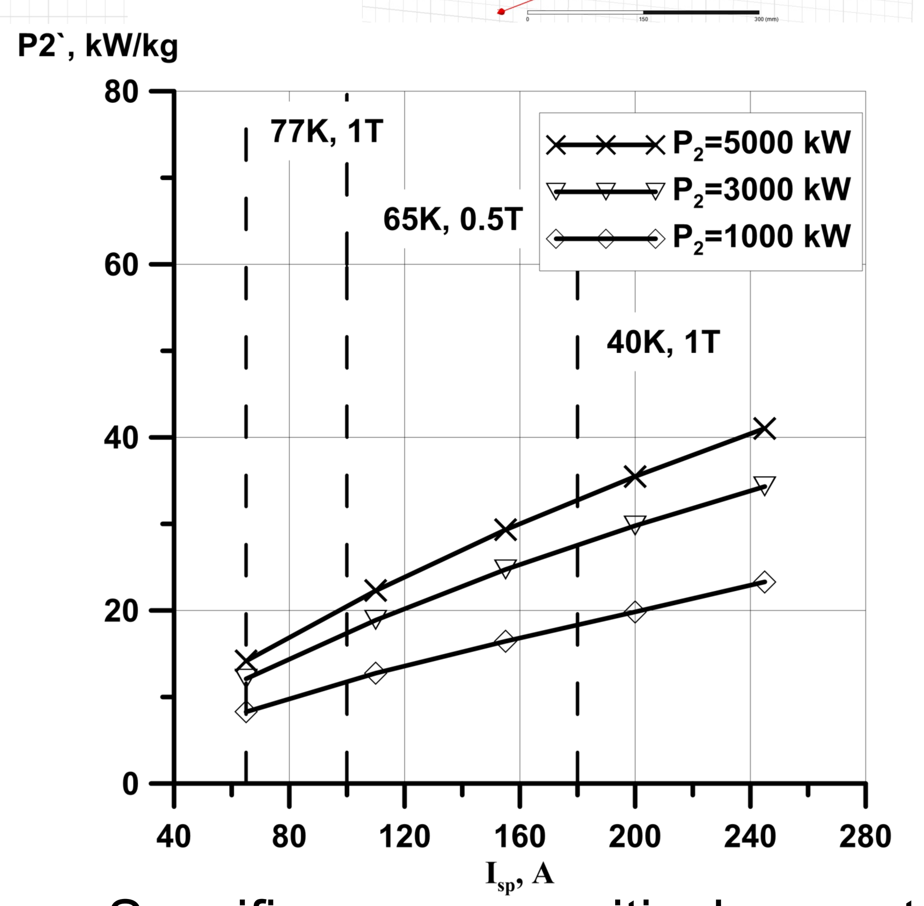




Specific power vs pole number

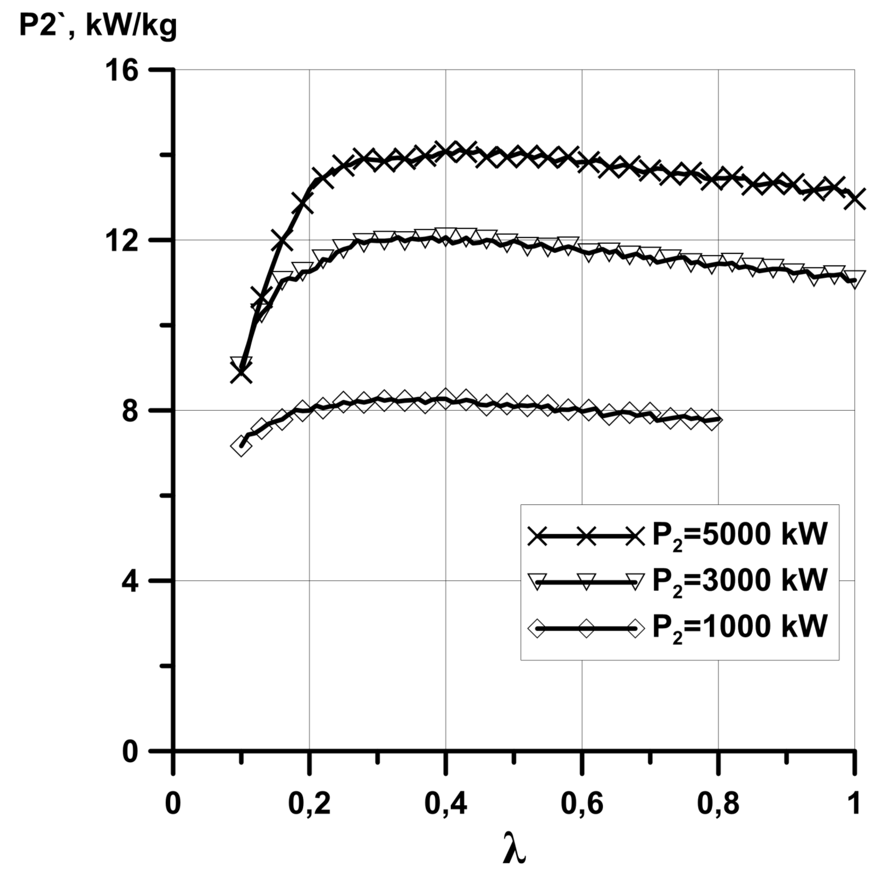


Specific power vs rotational speed

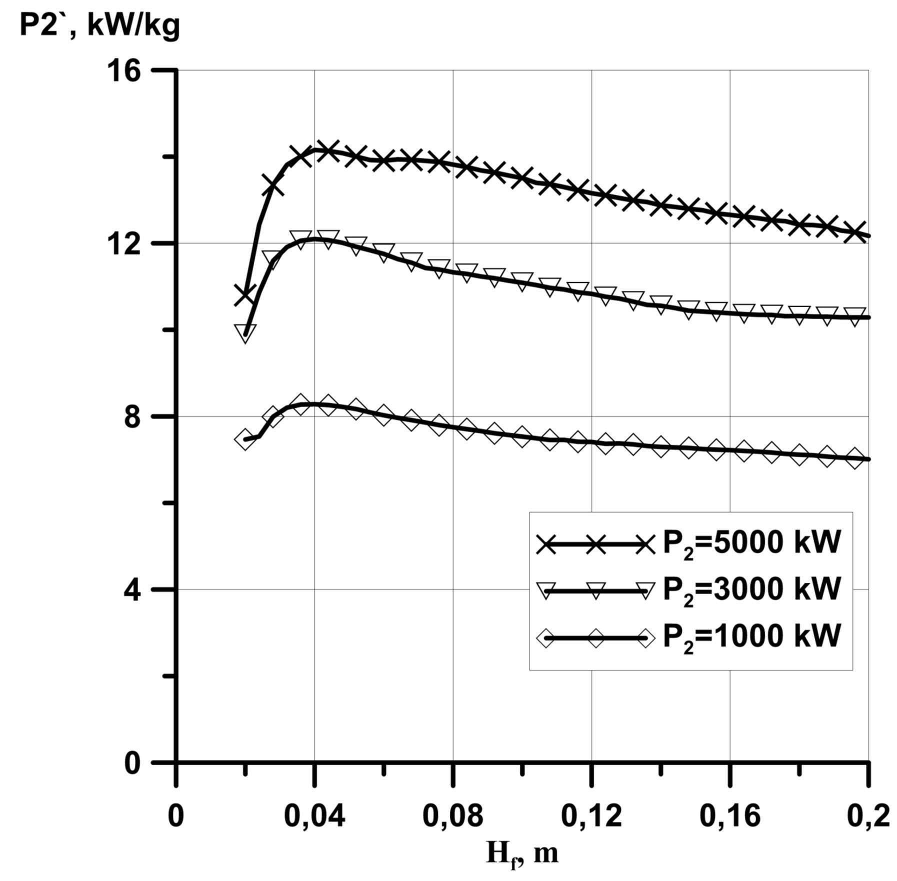


Specific power vs critical current

Parameter	Value		
Output power P_2, kW	1000	3000	5000
Specific power with cooling $P`_{2\_c}$, kW/kg	8.5	13.1	14.7
Specific power P'_2, kW/kg	11.2	17.9	20.1
Pole number p	6	8	8
Field winding height H_f, m	0.04	0.04	0.044
Stator inner radius R_{ai}, m	0.274	0.374	0.388
Current loading A_n, kA/m	250	260	265
Magnetic inductance in the air gap B_d, T	0.38	0.43	0.46



Specific power vs construction coeff.



Specific power vs height of field winding

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