



PM Motor Development in Switzerland, Applications and Efficiency Potential

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PM Motor Development in Switzerland, Applications and Efficiency Potential

- **A Step Forward**
- **„New“ Concepts**
- **Design problems of PM machines**
- **Experiences with large PM machines**
- **Profitability of large PM machines**
- **Lesson Learned**
- **Back-to-Back Test**
- **Conclusions**

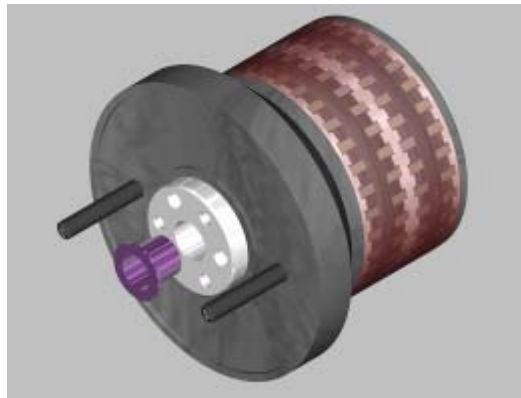


A Step Forward

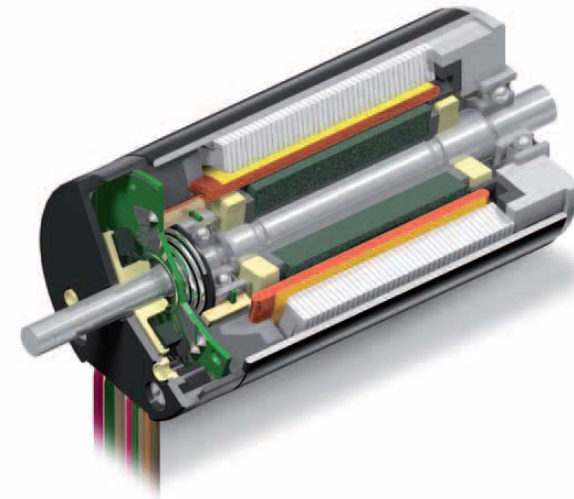




A Step Forward



maxon motor
driven by precision



MINIMOTOR SA

Portescap



Eisenlose Rotorspule System FAULHABER®

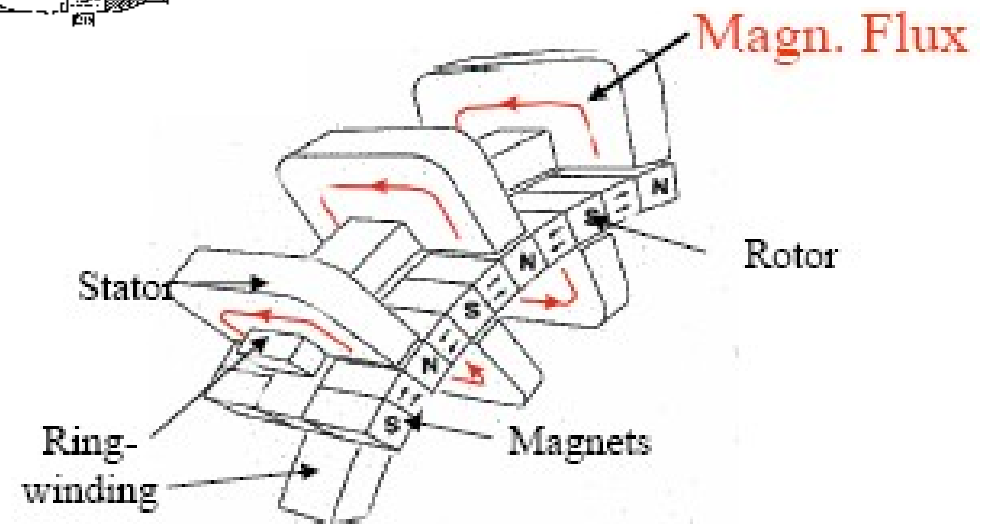
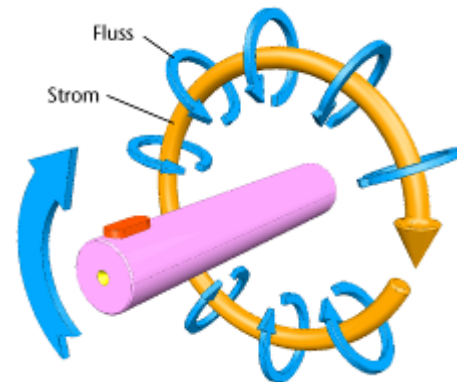
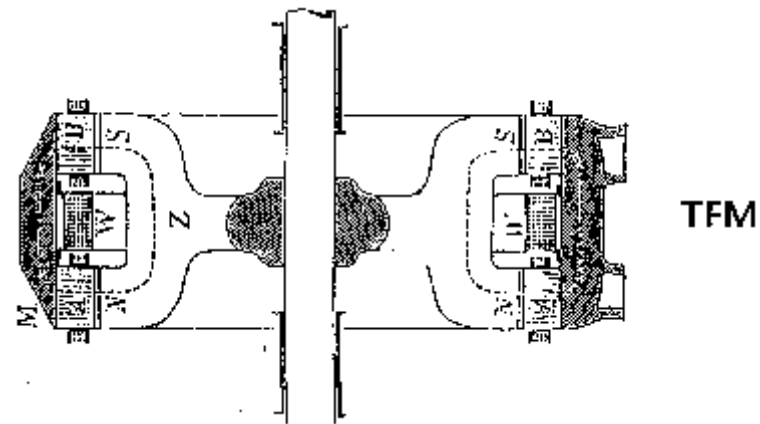


SONCEBOZ



„New“ Concepts

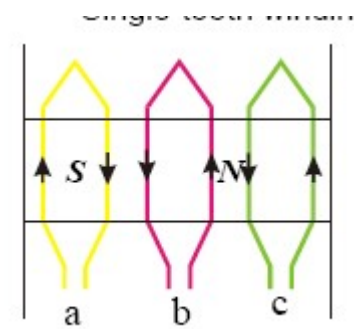
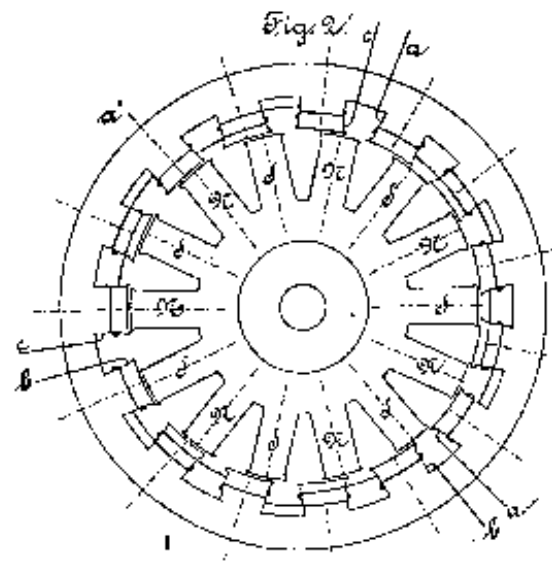
■ Mordey Patent 1895: Transversal flux machine



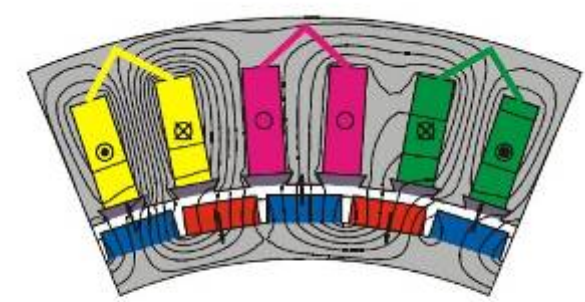


„New“ Concepts

■ AEG Patent 1905: Single tooth winding PM



Concentrated Windings



Air gap field:
AC-Field produced by individual coils



Design problems of PM machines

- Magnetic circuit design
- Load torque, pulsation, cogging torque and noise
- Operating parameters: $U, I, \cos\varphi, \eta$
- Losses in permanent magnets and iron
- Identification of L_d - L_q models for simulation
- Simulation of magnetisation and demagnetization
- Measurement of appropriate losses of the inverter fed pm machine
- => use of Finite Element calculation methods and nonstandard measurement methods

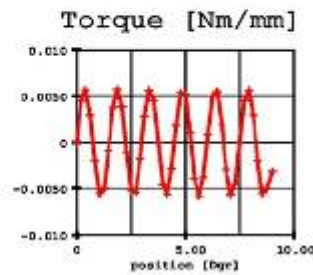
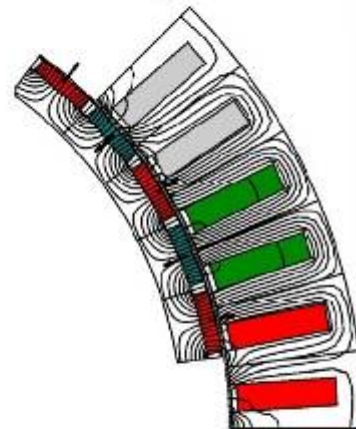


Design problems of PM machines

Cogging torque ($i = 0$):

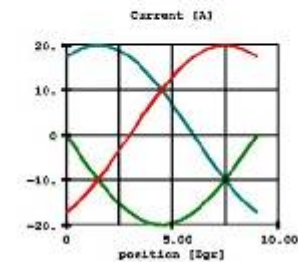
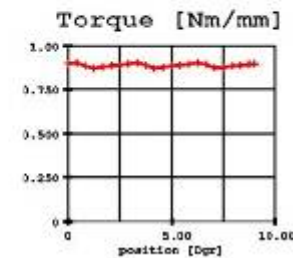
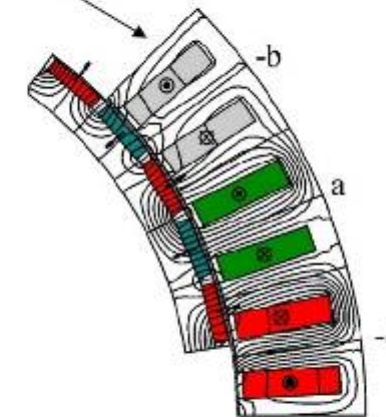
$$T = - \frac{\partial W_{magn}}{\partial \alpha}$$

Sector of a MM with 40 poles and 48 slots



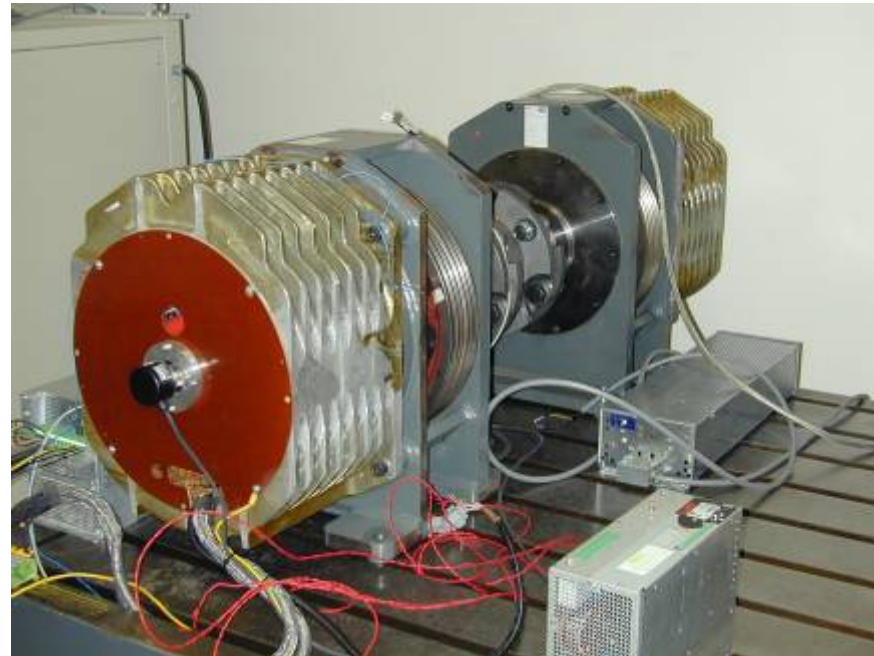
Load pulsation torque

$$T \approx \sum_{n=1}^m i_n \frac{e_n}{\partial \alpha / \partial t} = \sum_{n=1}^m i_n \frac{\partial \psi_n}{\partial \alpha}$$





■ Elevators



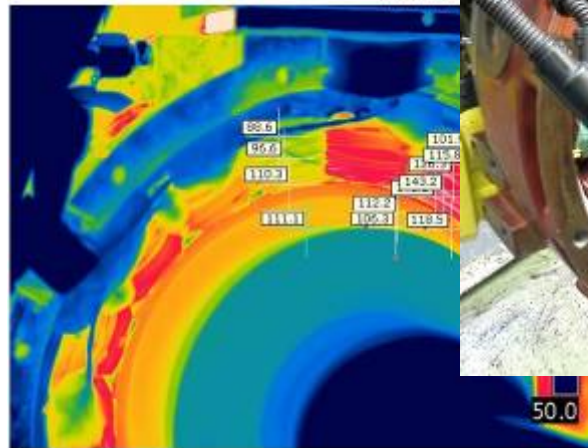
1500Nm, 46rpm, Back to Back test

- Gearless
- Less maintenance
- Good efficiency



Experiences with large PM machines

■ Hybrid



200Nm, 1500rpm

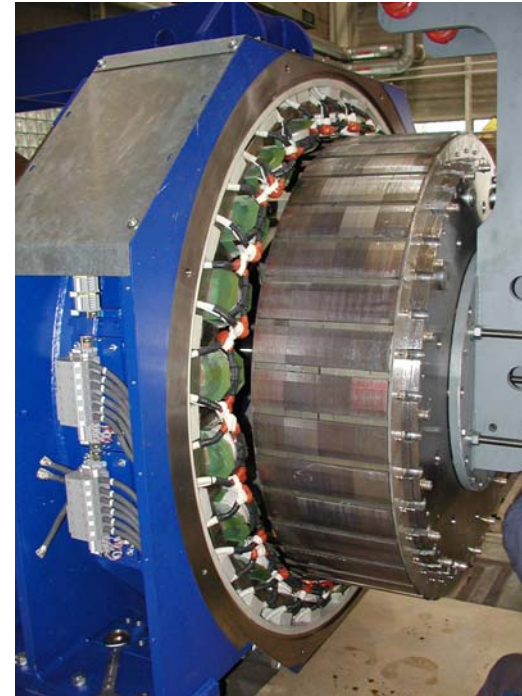
- „Cooling“ temperature 115GradC
- Fully integrated
- Vibration proof winding connection



Experiences with large PM machines

■ Elevator

- Less maintenance
- High reliability
- High efficiency
- High Torque (80kN/m^2)
- Single Bearing

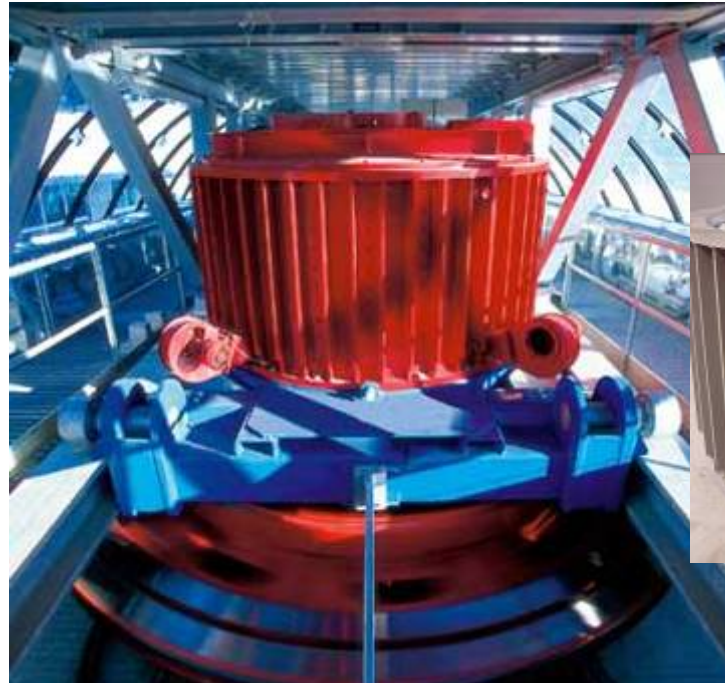


80kNm, 40rpm



Experiences with large PM machines

■ Ropeway

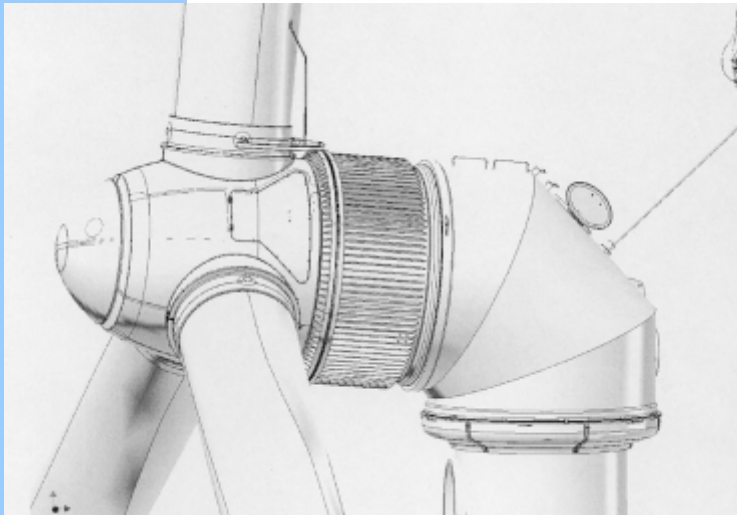


200kNm, 20rpm

- No Gear
- Less maintenance
- Good efficiency
- High reliability



■ Windenergy


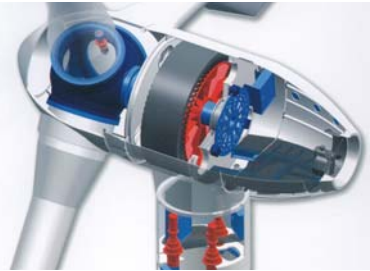
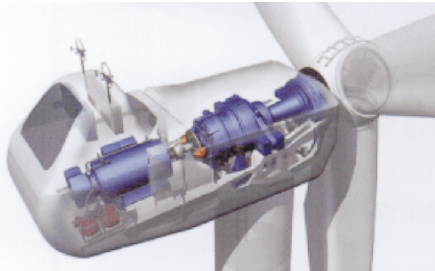


Windgenerator 1250 kVA, 21.5 1/min (Leitner)

- **Gearless**
- **High Efficiency**
- **Single bearing**




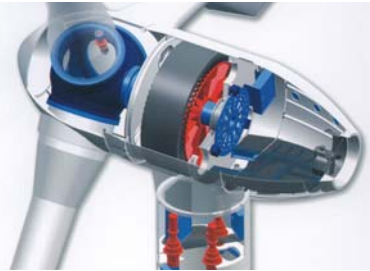
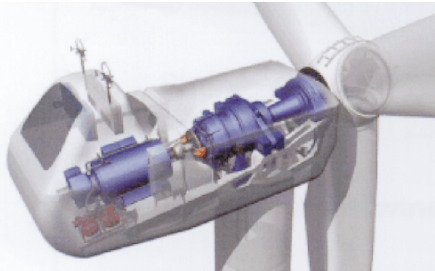
Experiences with large PM machines

Comparison Gearless vs Geard Windgenerator ⁽¹⁾	Gearless	With Gear
		
Weight@2MW	115 t	120 t
Efficiency El. Machine	97%	98.5%
Efficiency Gearbox	-	97%
Efficiency Inverter	97%	97%
Total Efficiency	94%	92.6%

⁽¹⁾ **STX Windpower B.V.**



Profitability of large PM machines

Comparison Gearless vs Geard Windgenerator (1)	Gearless	With Gear
		
Project investment	105%	100%
Maintenance Cost per Investment	5.9%	12.4%
Total cost during pay-back periode	10.9%	12.4%
Energy savings	1.5%	0%
Profit over 7years	2.9%	0%

(1) Pay-back time: 7 years



Lesson Learned

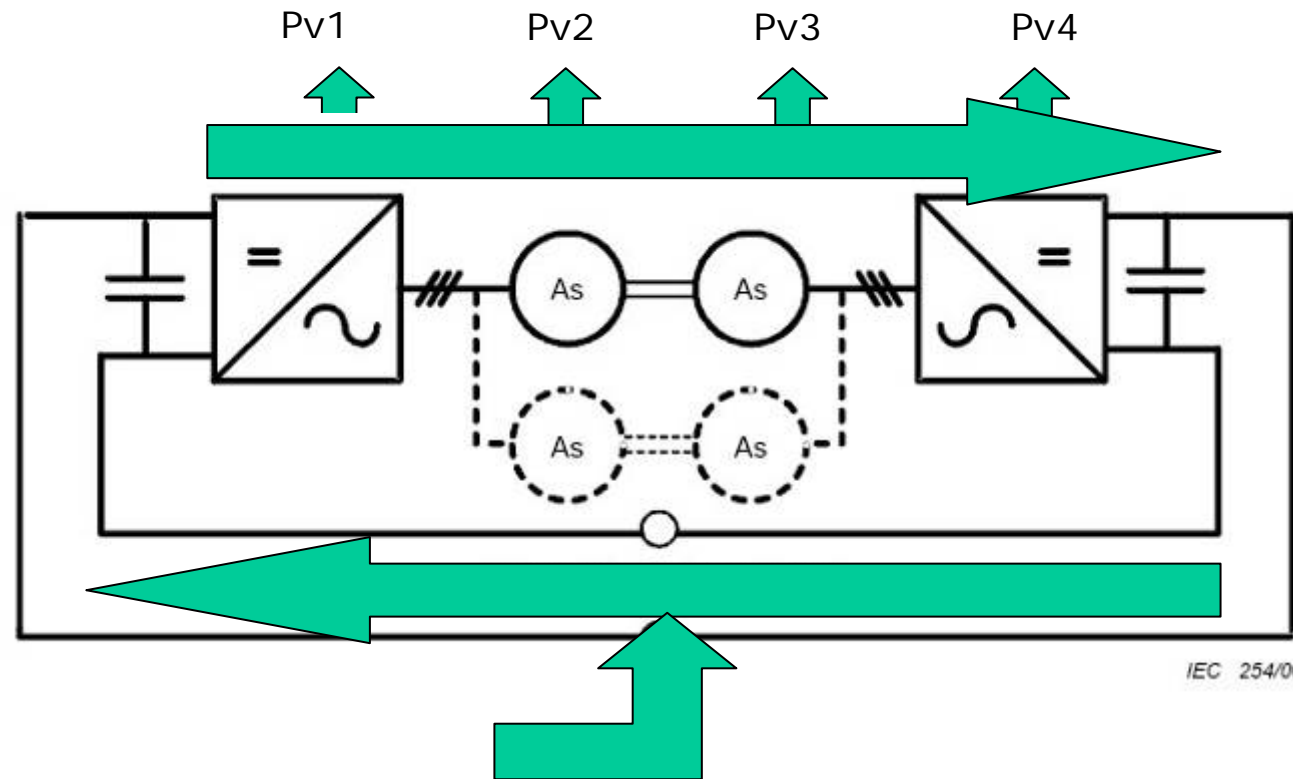
- **Although the investments are higher there is an acceptable pay back**
- **Customer will see the performance and efficiency**
- **Back to Back is the only feasible type test**
- **Iron losses are depending from current and current phase**
- **The controller needs reliable position signals**
 - e.g. from redundant resolvers



Back-to-Back Test

Railway applications –
Rolling stock –
Part 1:
Combined testing of inverter-fed alternating
current motors and their control system

CEI
IEC
61377-1

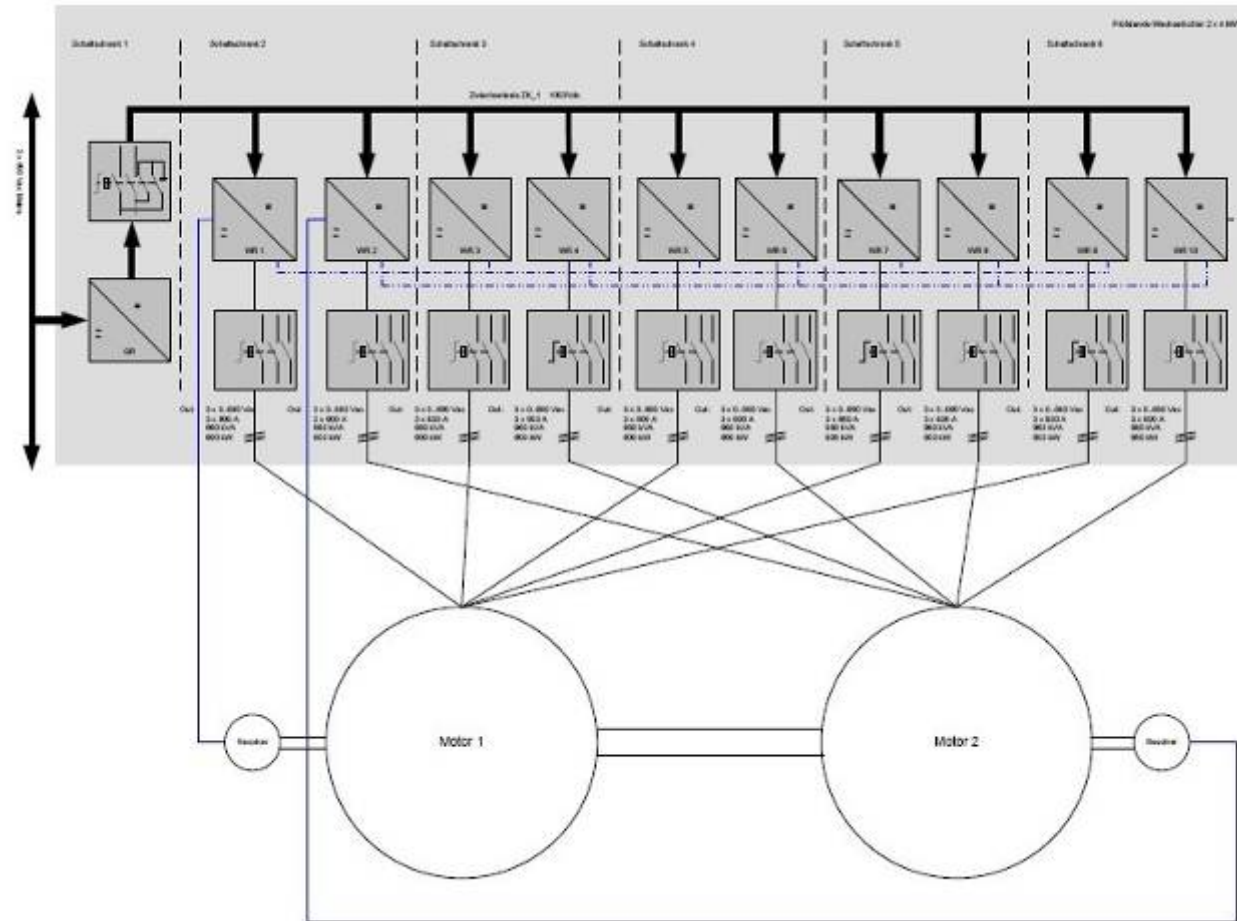


Grid Power: $Pv1 + Pv2 + Pv3 + Pv4$



Back-to-Back Test

Typical arrangement





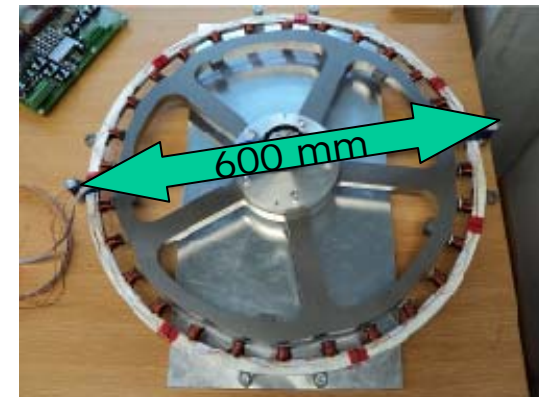
Advantages of Back-to-Back Test

- Lower accuracy of torque measurement needed (can be substituted by a torque estimator)
- Low grid load
- Paralleled motors possible
- High accuracy of loss measurement
- Straight forward evaluation of efficiency (balanced):

$$\text{Efficiency} = \frac{\text{mech Power} + (\text{Pv1} + \text{Pv2} + \text{Pv3} + \text{Pv4}) / 2}{\text{mech Power}}$$



Impressions from Back-to-Back Test





Lesson Learned

- Today we have a „single source“ situation of rare earth material





Conclusions

- PM production technologies have to be „reinvented“
- Increase the magnetic power of other material
- Develop additional machine topologies
(yes we have a lot to do !)



Thank you for your attention

MagnetDrives AG

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