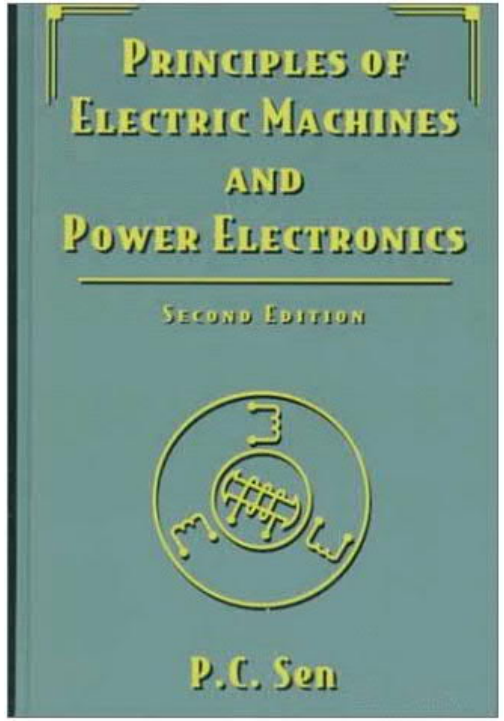
ELEC-E8407 Electromechanics (5 cr)



- **Information and Communication:** MyCourse portal.
- **Lectures and exercises:**
  - Tuesday 12-14 and 14:15-16:00
  - periods I and II.
  - All events are organized as distance learning over the internet
  - Some laboratory exercises could be organized is the situation allows for it
- **Lecturer:**
  - Prof. Anouar Belahcen: anouar.belahcen@aalto.fi; TUAS-3545
  - Assistants: MSc. Aswin Balasubramanian

- **Course material:**
  - P.C. Sen, Principles of Electric Machines and Power Electronics, 615 p.
    - Chapters 1-6

ELEC-E8407 Electromechanics

- **laboratory works** (if the situation allows for it):
  - Transformer on weeks 43-44 (19.10 – 30.10.2020)
  - Asynchronous motor drives on weeks 46-47 (9 – 20.11.2020)
    - Works are done in small groups (4 persons per group).
    - Pre- and post-reports are reviewed and graded
    - The pre-reports are personal and due 2 days before the lab works are done
    - The post-reports are group-wise (1 report per group) and due 2 weeks after the lab works
    - All reports are made with some text processing program.
    - No hand written report will be accepted.
    - Reports are submitted via MyCourse information system.
- **Examination:**
  - At the end of the course (Tue. 8.12, 12:30-15:30, distance exam over the internet)
  - Other exams will be arranged according to the re-take schedule of the school
  - To get the grade the laboratory works have to be accepted also.
  - If no laboratory work are possible, they will be replaced by other similar assignments

Course contents

- Introduction, Magnetic Circuits, Ch. 1
  - Mag. Materials, magnetic circuits, fundamentals of magnetism, power losses.
- Transformers, Ch. 2
  - Ideal transformer, single phase, three phases transformer and connections, equivalent circuit.
- Electromechanical Energy Conversion, Ch. 3
  - Forces, torques, energy.
- DC Machines, Ch 4
  - Construction, operation principles, steady-state calculations, principles of speed control.
- Induction Machines, Ch.5
  - Construction, rotating field, equivalent circuit, steady-state operations, losses.
- Synchronous Machines, Ch. 6
  - Salient-pole and cylindrical rotor, steady-state operation, equivalent circuit.

Course outcome

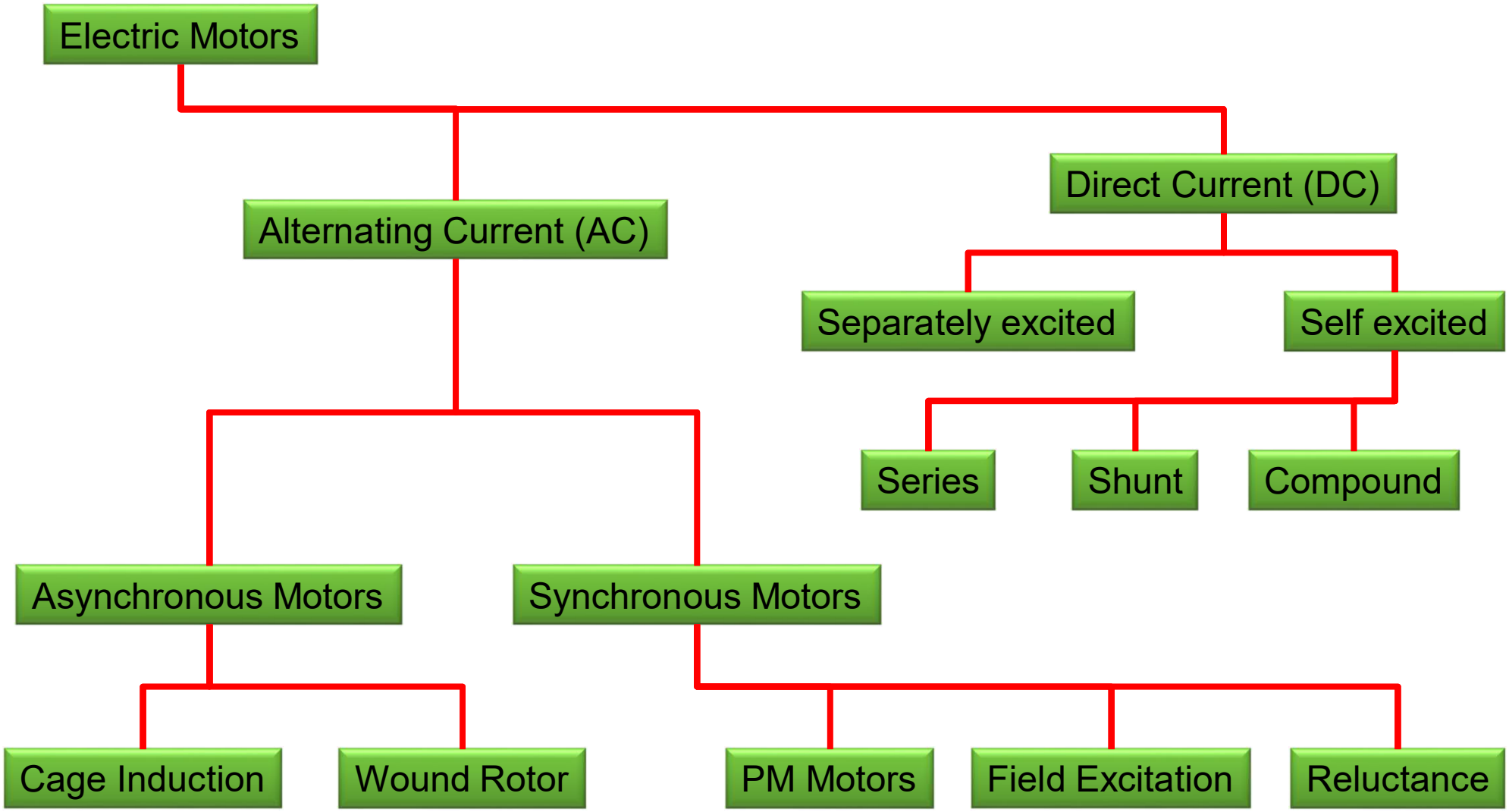
At the end of the course the student will be able to:

- Calculate the magnetic response of a magnetic circuit
- Explain the principles of electromechanical energy conversion and power losses
- Describe the construction of different electrical machine types and their operation
- Build an equivalent circuit of an electrical machine
- Use equivalent circuits to calculate the steady-state operation quantities of electrical machines

Generalities

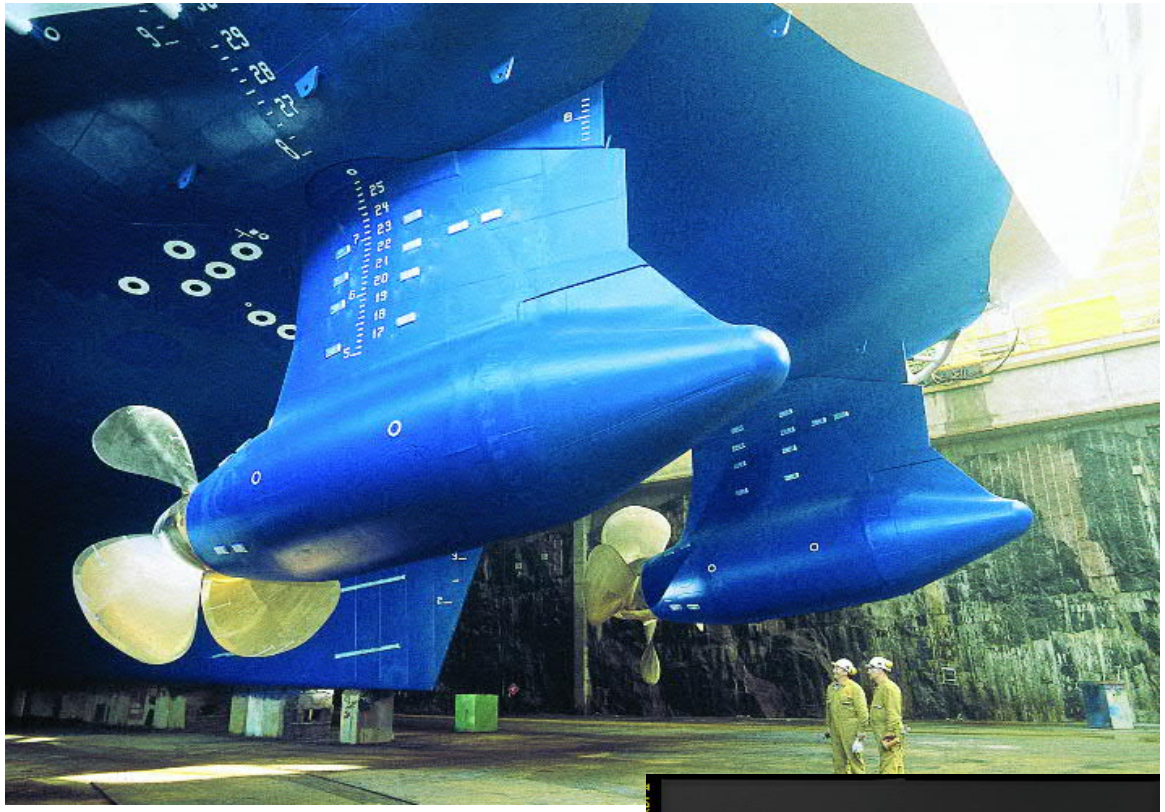
- Circa 100% of the worldwide electrical energy is produced by rotating electrical machines.
- More than 65% of the electrical energy is consumed by electric motors in different industry applications.
- Tightened requirements on energy efficiency could be answered by better motors and careful choice of motor drives.
- Multitude of motor drive solutions require analytical and multidisciplinary skills.

Classification of Electric Motors



Motor Applications

- Industry applications
  - Grinding
  - Milling
  - Pumping
  - Air compressing
  - Vacuum pumping
  - Hoists and lifts



- Transport

large starting torque, extended speed range

  - Electric vehicles
  - Rail transport
  - Cruises and ships

Generator Applications

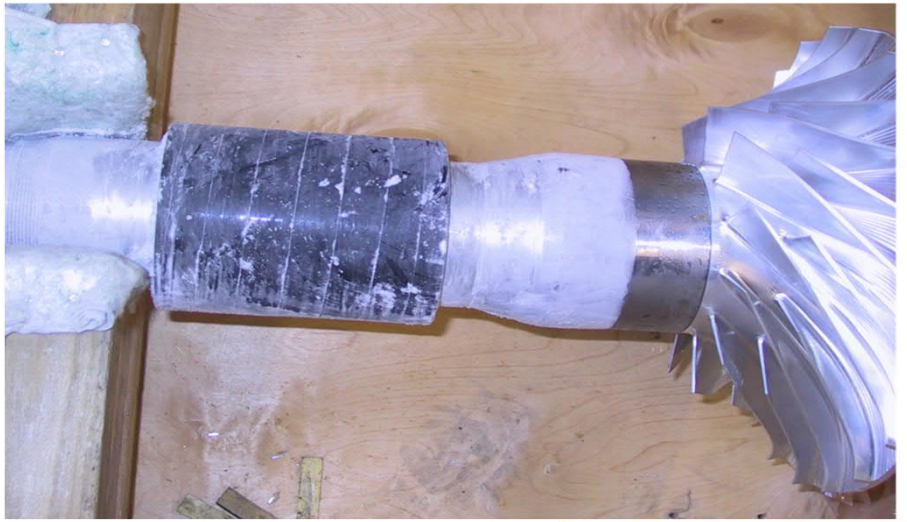
- Power plants
  - Hydropower plants – low speed, large number of poles, salient
  - Thermo and nuclear power plants – High speed 2-4 poles cylindrical turbogenerators
- Wind power
  - Cage induction machine
  - Doubly Fed IG (DFIG)
  - PM machines
- Emergency power supply
  - Salient pole synch machine
  - voltage regulation
- Car industry
  - DC generators
  - alternators

High-speed motors

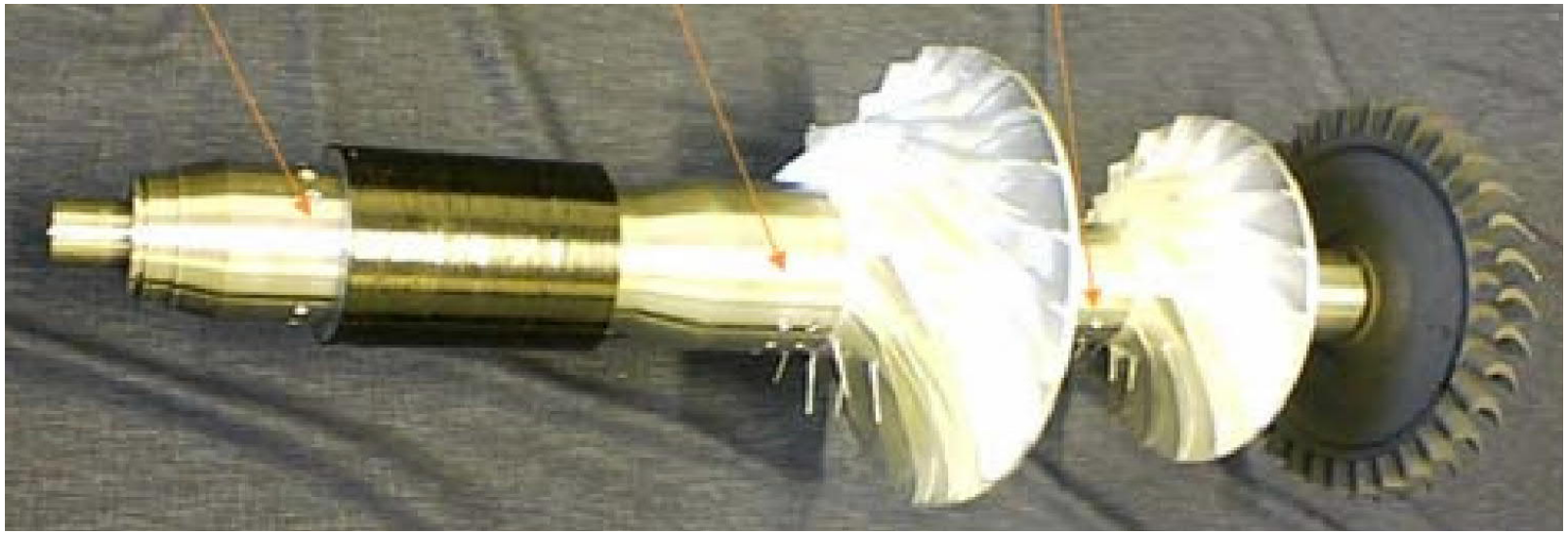
Power	65 kW
Voltage	400 V
Current	150 A
Supply	VSI
Speed	30600 $^{1}/_{min}$
Stator winding	3 phase, full pitch
Stator connection	DD
Stator slots	36
Poles	2
Insulation class	F
Cooling	Forced air cooling
Bearings	AMB
Load	Air compressor

Application of high-speed motors

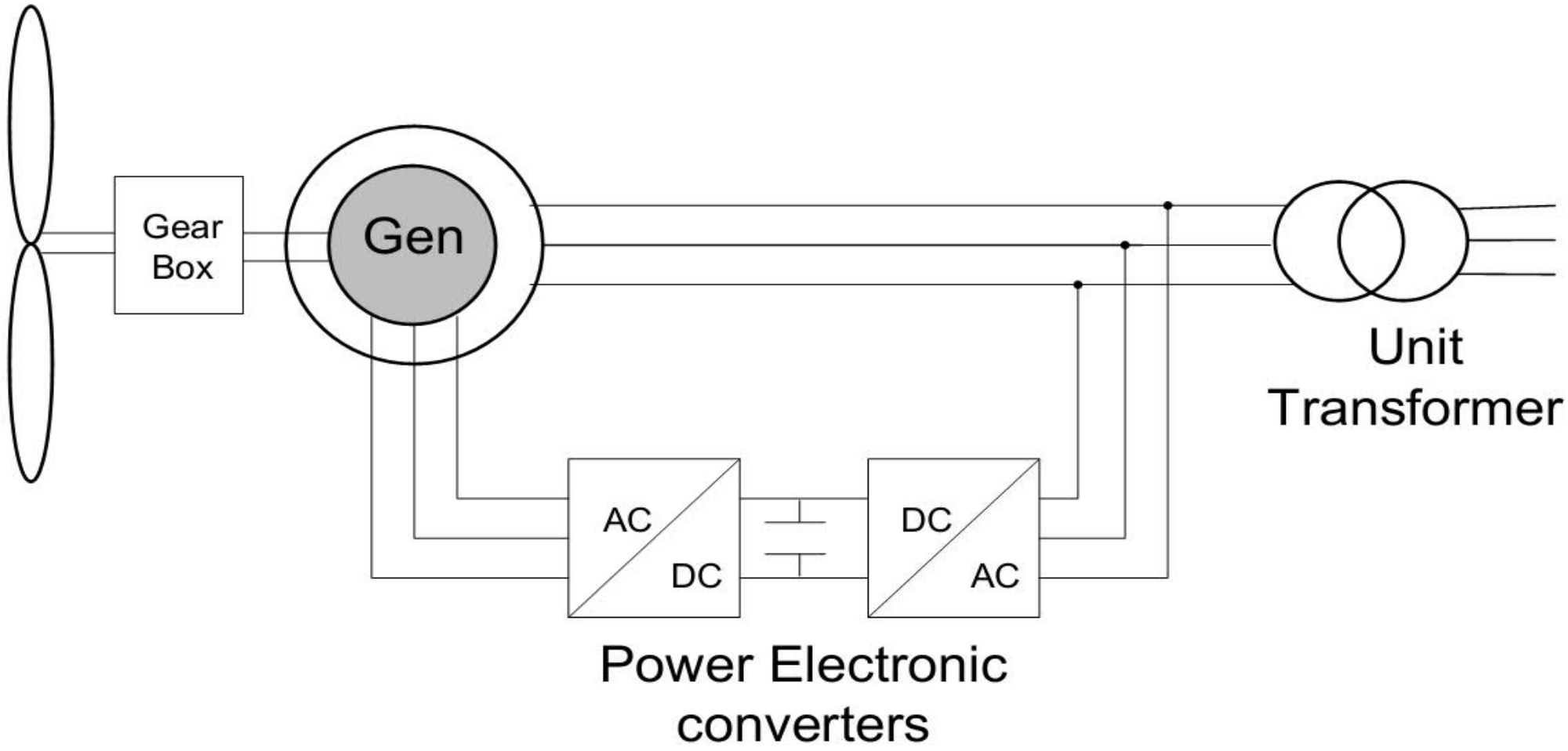
- The load machine is mounted on the same shaft as the rotor of the electrical machines
- Hot air blowers
- Turbo compressors
- Turbochargers
- Cooling and rotor dynamic problems



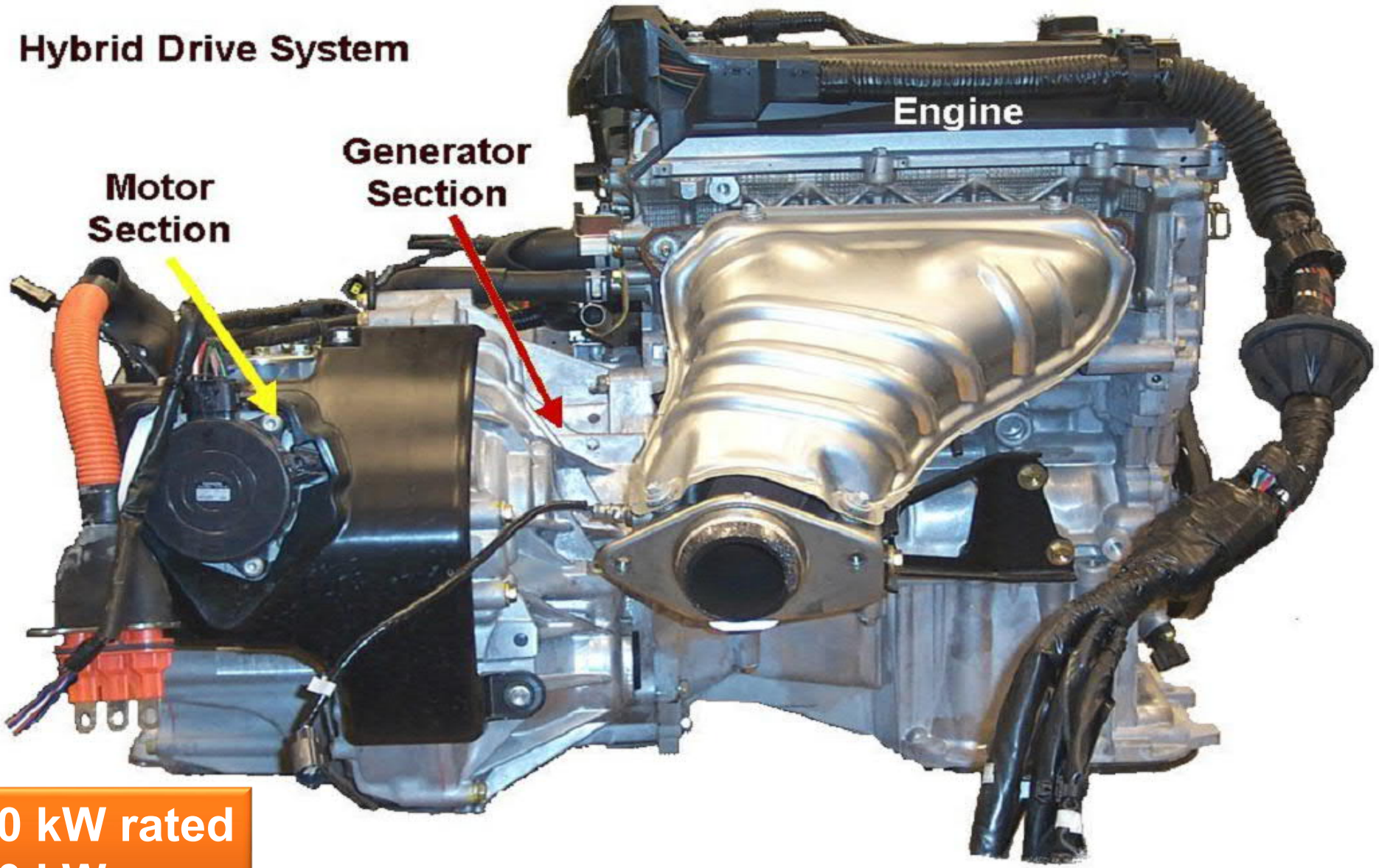
130 kW
31 500 rpm



Doubly-fed Induction generator

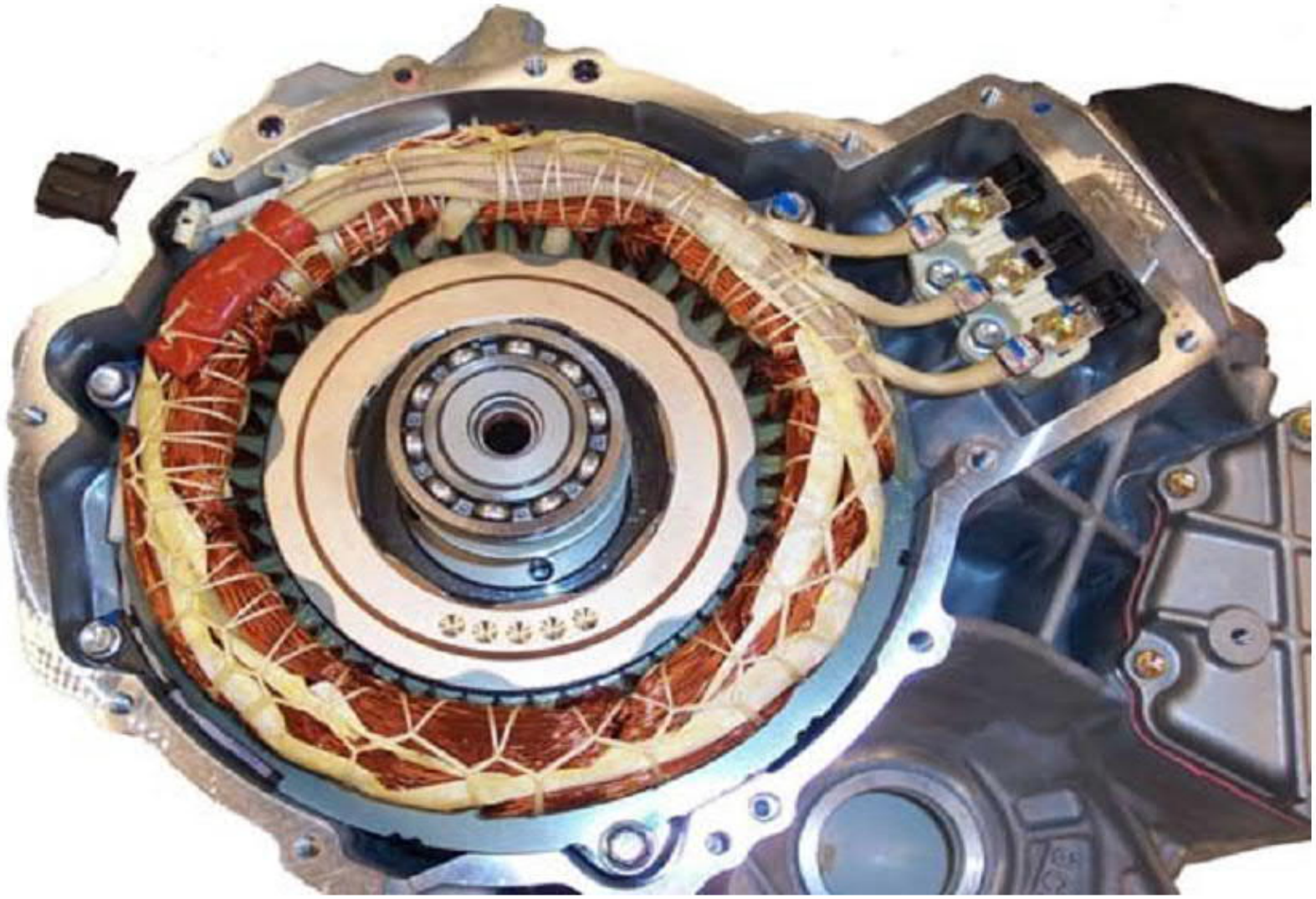


Prius hybrid



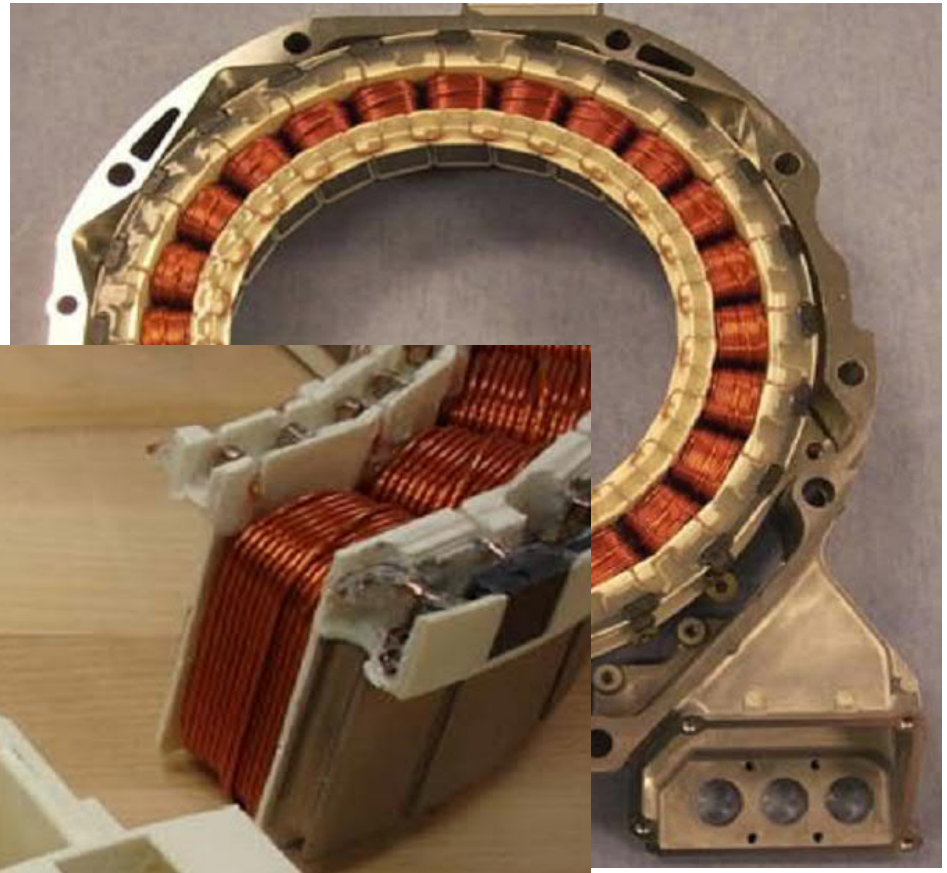
40 kW rated
50 kW max

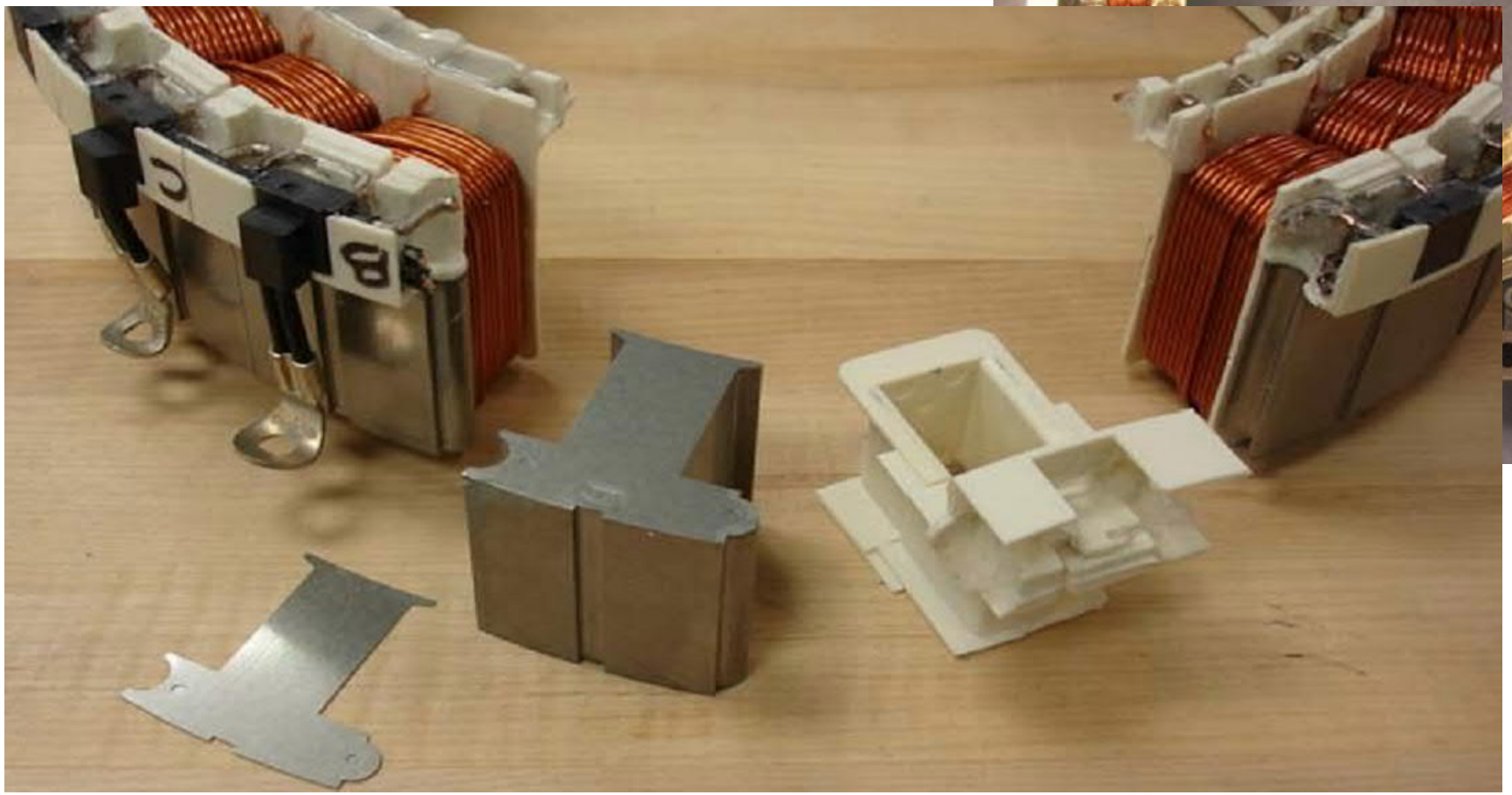
Prius hybrid



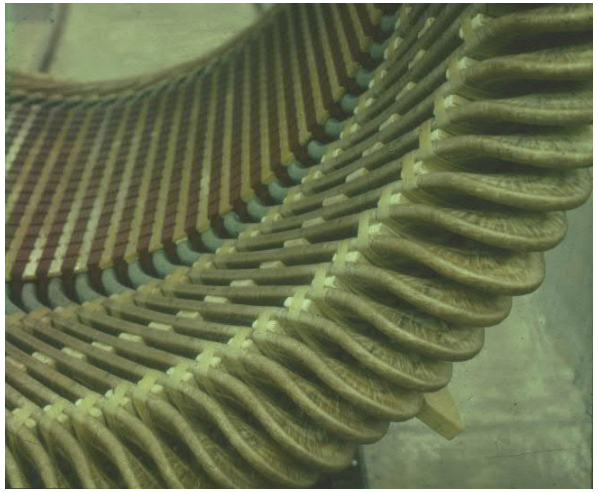
Honda motor

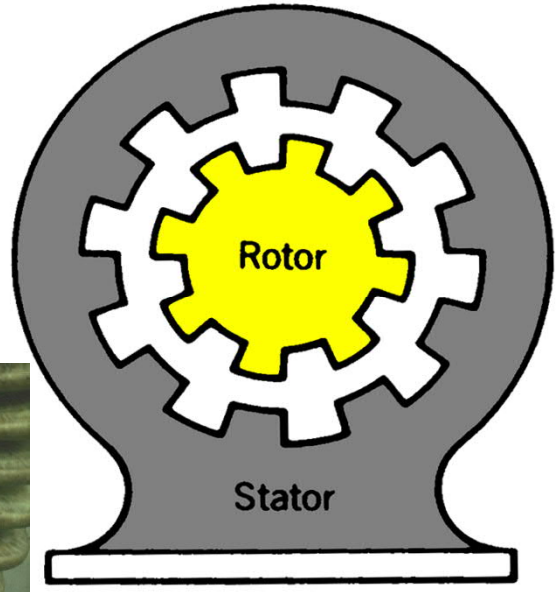
12 kW rated
15 kW max



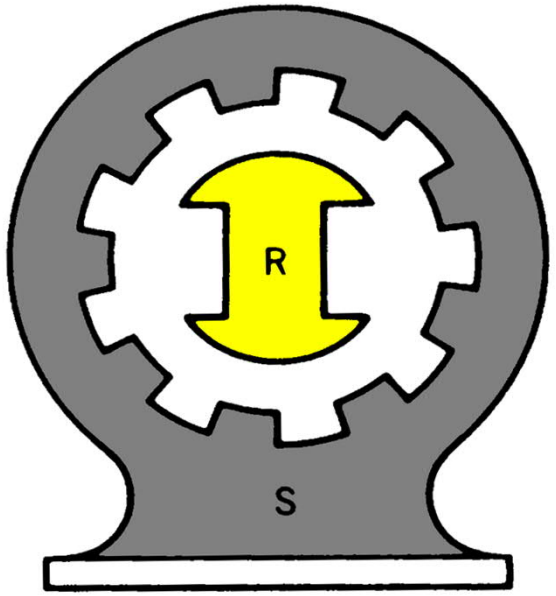


Basic structure of electric machine

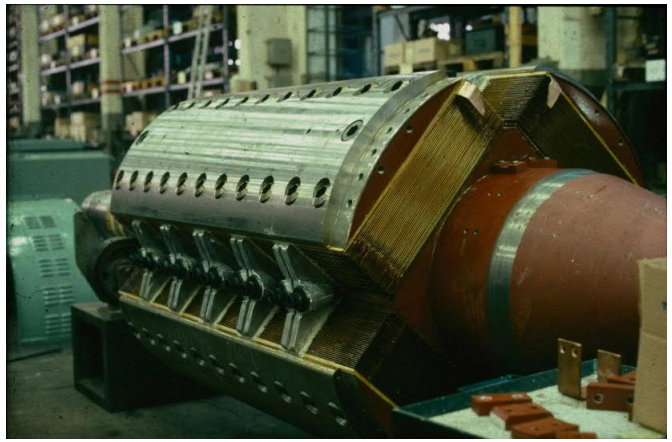




Cylindrical machine
Uniform air gap



Salient pole machine
Non-uniform air gap



- Slots with conductors
- Iron core
- Laminations