Driveline and Chassis Technology

ZF Sachs Race Engineering GmbH

Sven-Martin Osterroth, Development Engineer

Company Structure

ZF Friedrichshafen AG
Shareholders: 93.8 % Zeppelin Foundation, Friedrichshafen / 6.2 % Dr.-Jürgen-Ulderup Foundation, Lemförde
Corporate Headquarters and Corporate Research & Development, Friedrichshafen

Divisions	Business Units
Car Driveline Technology	Rubber-Metal Technology
Car Chassis Technology	Marine Propulsion Systems
Commercial Vehicle and Special Driveline Technology	Aviation Technology
	Aftermarket Trading
Off-Road Driveline Technology and Axle Systems	Sales and Service Organization
Powertrain and Suspension Components	**Regions**
Steering Technology – ZF Lenksysteme GmbH A joint venture with Robert Bosch GmbH	North America
	South America
	Asia-Pacific

Research and Development
Main Development Locations

Friedrichshafen
Germany

Dielingen
Germany

Schweinfurt
Germany

Passau
Germany

Schwäbisch Gmünd
Germany

Northville
USA

Company History ZF Sachs AG (1)

1895	August 1, Ernst Sachs and Karl Fichtel established „Schweinfurter Präzisions-Kugellagerwerke Fichtel & Sachs“
1903	The „Torpedo“ freewheel for bicycles is introduced – the company experiences rapid growth
1923	The company goes public
1929	Sale of ball bearing divisions and commencements of activities in the field of automotive motors, clutches and shock absorbers
1945	Reconstruction of manufacturing facilities begins (67% were destroyed in WW II)
1959/60	The first subsidiary is established: Amortex S.A. (Clutches), Sao Paulo (Brazil)
as of 1965	The product range is expanded and activities in the automotive sector are increased through establishment and acquisition of several companies in Germany and abroad
1987	Mannesmann AG acquires the shares in Fichtel & Sachs AG
1994	New development center for automotive parts and systems in Schweinfurt begins operation
1997	Fichtel & Sachs AG is renamed Mannesmann Sachs AG. New company structure with focus on the automotive business. Improved internationalization achieved through the acquisition of plants in Argentina and Mexico

Company History ZF Sachs AG (2)

1998	New production sites in Mexico, China and Turkey and also Sachs Race Engineering are established
1999	Introduction of the DynaStart CSG Joint-Venture for shock absorber production in China (Shanghai Huizhong)
2000	Breakup of the Mannesmann Group
2001	Strengthening of our position in Asia with plants/ joint-venture in Korea, China and Japan ZF Friedrichshafen acquires 100% of the Mannesmann Sachs AG shares, Mannesmann Sachs AG is renamed in ZF Sachs AG
2002	Boge and Elastmetall merge in ZF Boge Elastmetall. LMI and Sachs Handel merge in ZF Trading business units. ZF Sachs doubles capacity at Development Center
2003	Inauguration of a new production site of railway vehicles dampers in Shanghai, China Inauguration of the new Development Center in Schweinfurt, Germany
2004	Joint-Venture with MTI for Sachs Gießerei, Kitzingen Inauguration of the ZF Sachs Logistic Center in Troisdorf, Germany
2005	Selling of the subsidiaries Sachs Automotive France SAS and Sachs Gießerei GmbH. Founding of the new Joint Venture ZF Dongfeng Shock Absorber Shiyan Co. Ltd. in China for production of shock absorbers for commercial vehicles

ZF Sachs Race Engineering

- ZF Sachs Race Engineering was founded in 1998 as an independent subsidiary of ZF Sachs.
- We develop, design, and produce damper and clutch systems for racing cars and high-performance production series vehicles.
- Our goals include raising the profile of ZF and ZF Sachs on the international market as well as strengthening the image of our own organization.
- We benefit from the resources of the Development Center at ZF Sachs AG, which features the latest development and testing equipment available in the motorsports industry.

ZF Sachs Race Engineering Subsidiary and Partner

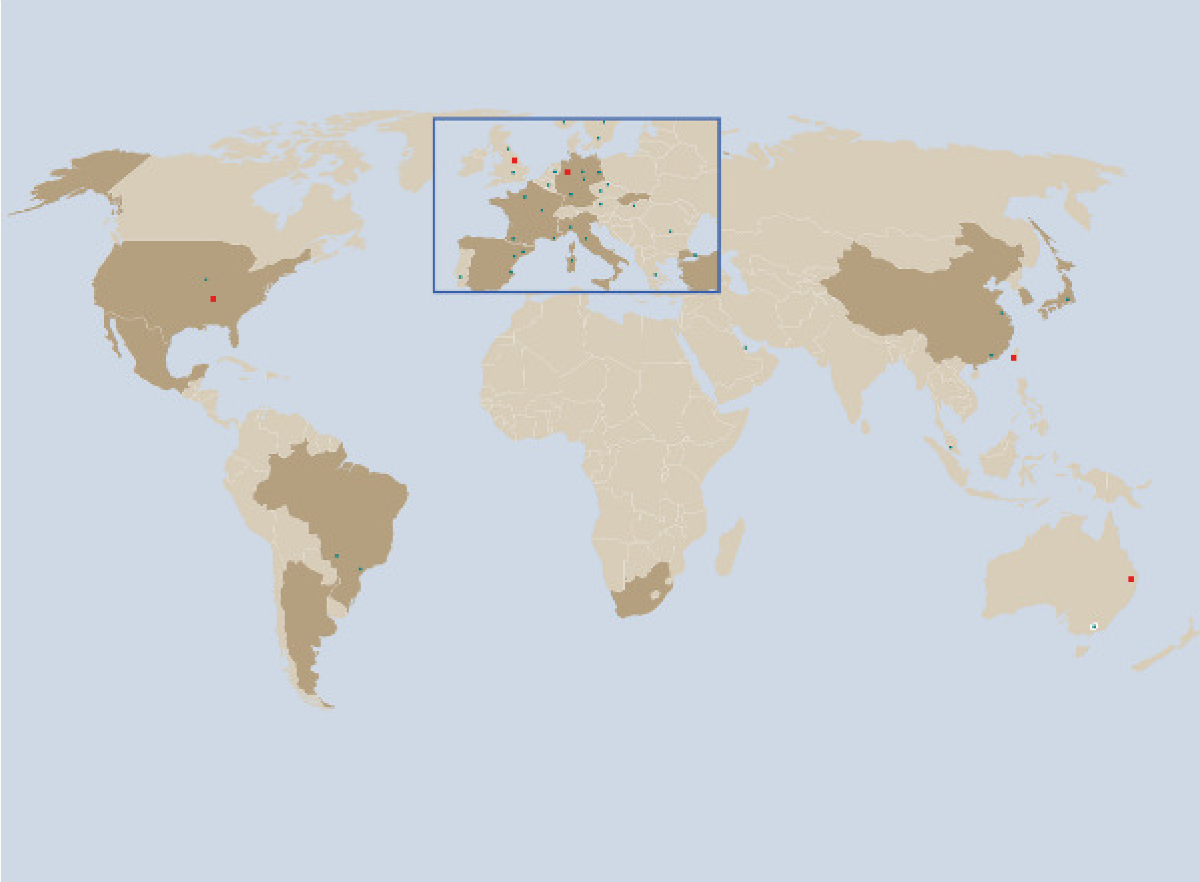
USA:
Subsidiary
ZF Sachs Race Engineering
North America

Germany:
Cooperation- and service
partner Galladé
Technologiezentrum
Nürburgring

Great Britain:
Service- and sales partner
Competition Braking Products

Australia:
Service- and sales partner
Triple Eight Race Engineering
Australia Pty Ltd.

Japan:
Service- and sales partner
Enable Inc.



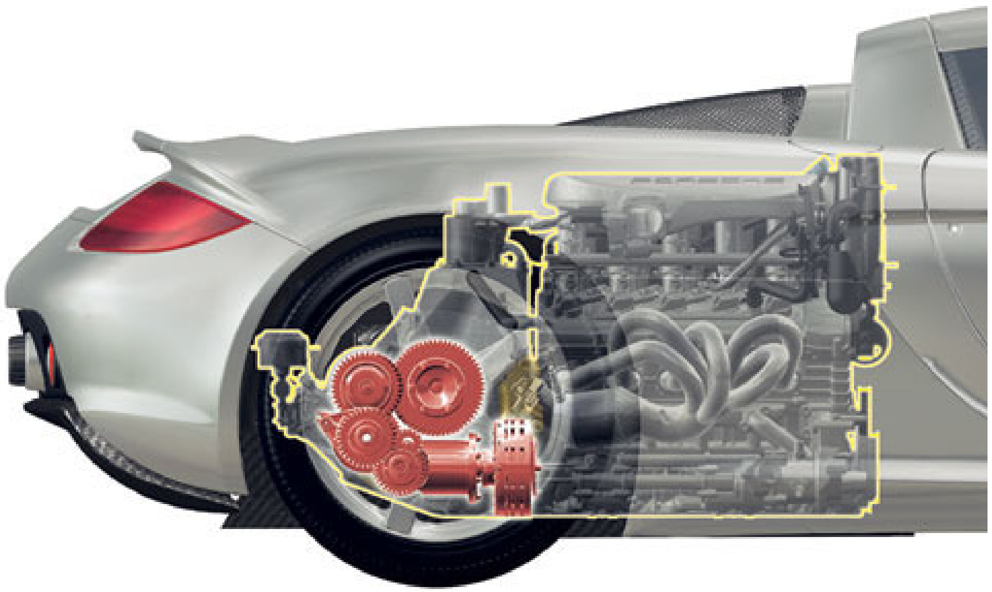
■ Location subsidiary / partner ■ Presence on the race track

ZF Sachs Race Engineering Target Groups

FORMULA	RACING	PERFORMANCE
High-End Motorsport	Motorsport Matrix Systems	Tuning products for street application

How to improve performance by reduction of drive train inertia

- Optimization of mass and inertia of flywheel, clutch and starter ring gear



Reduction of drive train inertia

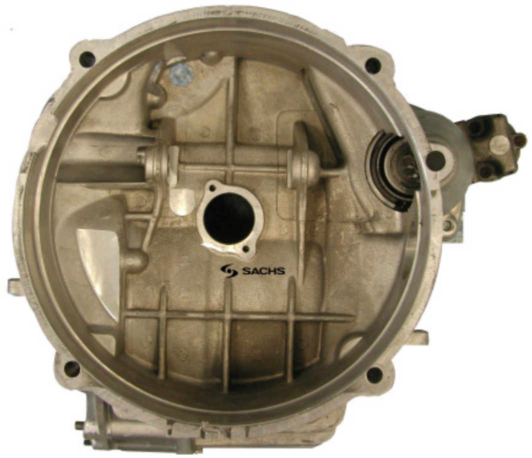
Car standard clutch

- Dual mass flywheel, friction plate, pressure plate
- High inertia
- Attenuation of vibration
- Quiet running
- Comfortable starting

Reduction of drive train inertia

Racing application

- Weight reduced flywheel
- Weight and diameter reduced clutch
- Original starter position



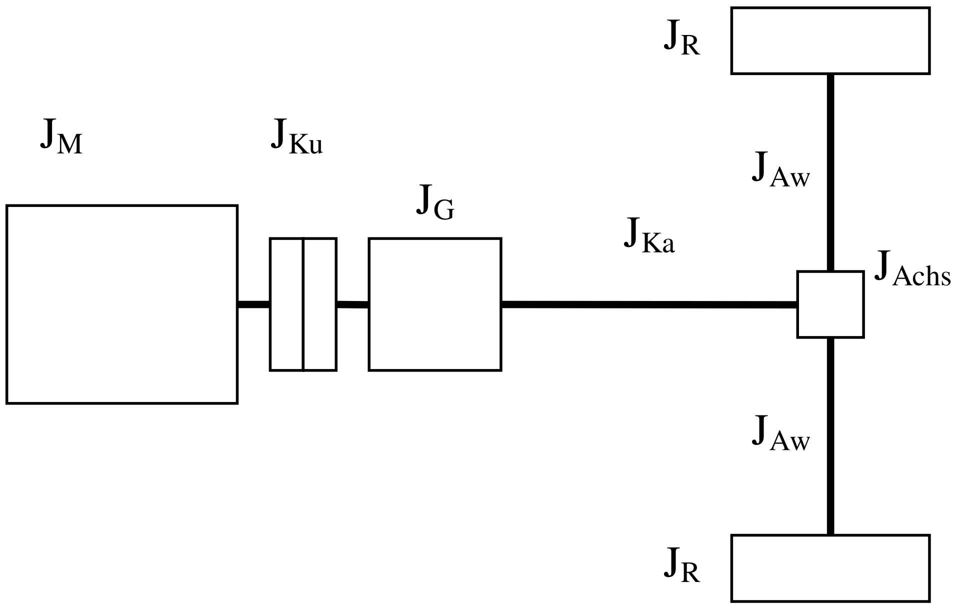
Influence of drive train inertia

- Inertia

  $J = m \times r^2$

- Gear ratio = i

$$\Delta m_{car} = \frac{\Delta J \times i^2}{r_{wheel}^2}$$



- Example:

  Standard clutch GMF 1/240 → J = 0,0610 kgm²

  10 % Reduction → ΔJ= 0,0061 kgm²

  1. Gear ratio 13,4:1

$$\Delta m_{car} = \frac{0{,}0061 kgm^2 \times 13{,}4^2}{(0{,}275 m)^2} = 14{,}48 kg$$

Reduction of drive train inertia

Racing clutch system

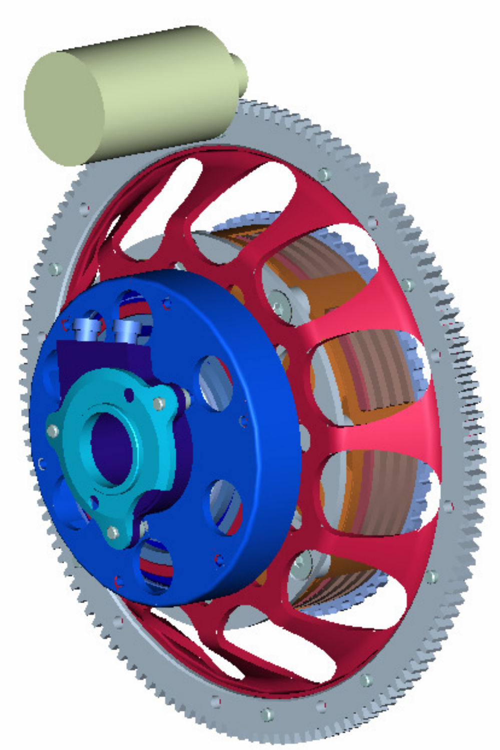
- Minimized clutch dimension
- Lightweight flywheel with original diameter
- Reduced mass and inertia

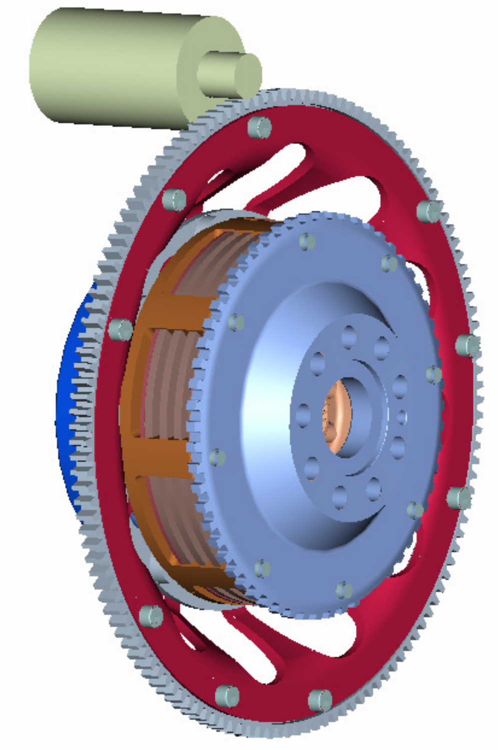
but

- Useless rotating mass

Reduction of drive train inertia

- Disconnection of starter ring gear from rotating clutch





Disconnection with freewheel

Freewheel – different types

- Roller type / sprag freewheels
  - Low to medium overrunning speed
  - Instant torque transmission
  - High torque capacity
  - Lubrication necessary

Disconnection with freewheel

Freewheel – different types

- Centrifugal forced sprag freewheel
  - Up to high overrunning speed
  - Instant torque transmission
  - High torque capacity
  - No lubrication necessary

    but
  - Rotating freewheel →

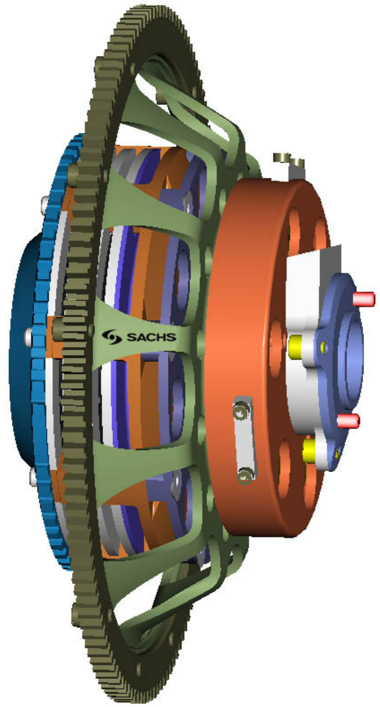
    increasing mass and inertia
  - Small distance between

    clamp-body and shaft (approx. 0,15 mm)

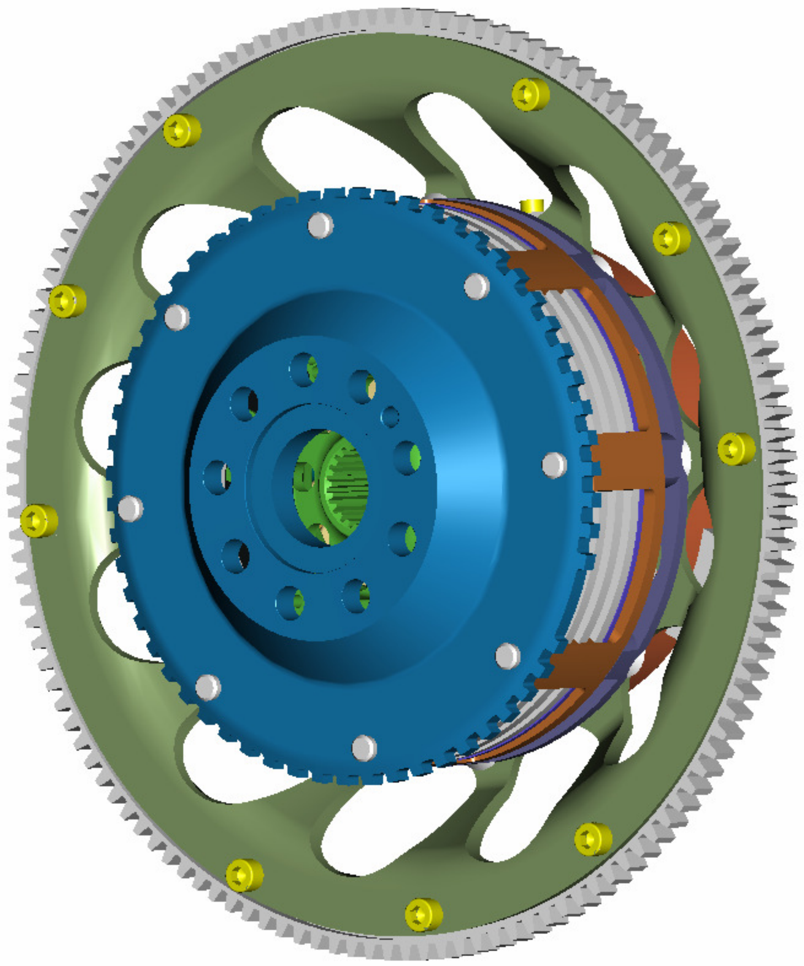
Disconnection with lift-off freewheel

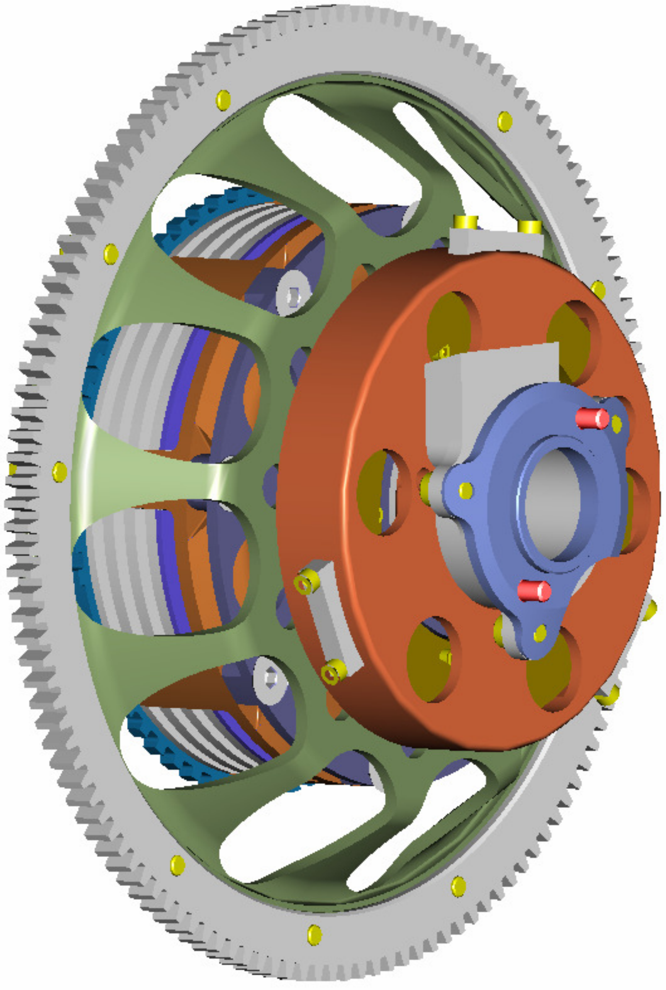
Lift-off freewheel

- Complete disconnection: freewheel - shaft
- High overrunning speed
- No rotating freewheel
- High torque capacity
- No lubrication
- Big distance between clamp-body and shaft (approx. 1,50 mm)



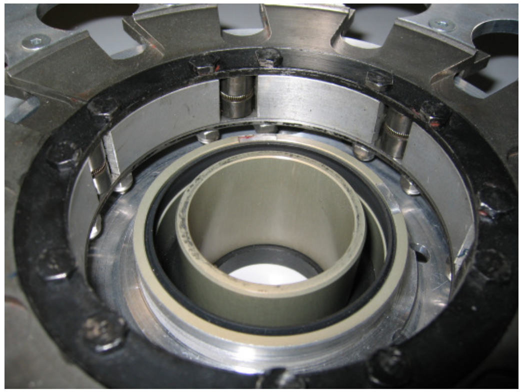
Disconnection with lift-off freewheel





Disconnection with lift-off freewheel

- **Characteristic:**
  - Small flywheel diameter (176 mm)
- **Advantages:**
  - Very low moment of inertia
  - Low weight
  - Standard starter can be kept
- **Disadvantages:**
  - More axial space is needed
  - 1 kg more total weight



Disconnection with lift-off freewheel

Comparison of rotating mass

- ZF SRE flywheel and clutch

  m = 3,11 kg + 1,98 kg = 5,09 kg

  J = 0,03395 kgm² + 0,0066 kgm²= 0,04055 kgm²

- ZF SRE flywheel and clutch with lift-off freewheel system

  m = 1,91 kg + 1,98 kg = 3,89 kg

  J = 0,00477 kgm² + 0,0066 kgm²= 0,01137 kgm²

$$\Delta m_{car} = \frac{\Delta J \times i^2}{r_{wheel}^2}$$

$$\Delta m_{car} = \frac{0{,}02918\,kgm^2 \times 13{,}4^2}{(0{,}275\,m)^2} = 69{,}28\,kg$$

Thank you for your attention!