EVERY GRAM COUNTS.
LIGHTWEIGHT DESIGN FOR SHOCK ABSORBERS IN MODERN PASSENGER CARS.
### Requirements for lightweight shock absorber design

### General design overview and the development of damper mass reduction over the last decade

### Current ‘state of the art’ lightweight shock absorber design

### Detailed examples of current lightweight damper design

### Future trends
REQUIREMENTS FOR LIGHTWEIGHT DAMPER DESIGN
DEMANDS CHANGE – COMPLEXITY INCREASES.

<table>
<thead>
<tr>
<th>Year</th>
<th>Model</th>
<th>Requirements / Demands</th>
</tr>
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<tbody>
<tr>
<td>1929</td>
<td>BMW 3/15</td>
<td>reliability and “comfort”</td>
</tr>
<tr>
<td>1937</td>
<td>BMW 328 Mille Miglia</td>
<td>faster / lightweight, aerodynamics</td>
</tr>
<tr>
<td>1957</td>
<td>BMW 507</td>
<td>“prestige” vs. “cheap”</td>
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<tr>
<td>1975</td>
<td>BMW 3 Series</td>
<td>sporty, design, comfort, and affordable</td>
</tr>
<tr>
<td>2012</td>
<td>BMW X3</td>
<td>dynamic, aesthetic, utility, premium, economic, sustainable, worldwide…</td>
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REQUIREMENTS FOR LIGHTWEIGHT DAMPER DESIGN
INCREASING DEMANDS CHALLENGE DAMPER DESIGN.

Passenger Cars
- More stringent legal requirements / Homologation
- Higher customer expectations (comfort, joy, design, space, reliability, brand image, ...)
- Increased engine output / loads
- Higher function & quality / less cost & weight

Damper
- Function, Quality, Cost, Weight, ... (Assembly, Service, Durability, ...)
- Recycling / Sustainability
MOTIVATION FOR LIGHTWEIGHT DESIGN
WEIGHT REDUCTION IS ESSENTIAL!

- Less weight ➔ more performance / kg
- Less weight ➔ less un-sprung mass / more comfort
- Less weight ➔ less fuel consumption
- Less weight ➔ less package space

➔ 3 main drivers for lightweight damper design using the example of fuel cons.
- CO₂-commitment of automotive industry
- Electrification - compensation of higher mass due to energy-/battery pack
- Sustainability - reasonable use of resources (lifetime energy consumption)

-1kg = -0.085 g CO₂/km
➔ Around -12,750 kg CO₂/car
(over lifetime, assuming average mileage 150,000 km)

Reference: Internet
EVERY GRAM COUNTS.
LIGHTWEIGHT DESIGN FOR SHOCK ABSORBERS.

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GENERAL DESIGN OVERVIEW
WEIGHT DEPENDS ON DAMPER CONCEPT.

Basic hydraulic concepts in automotive industry
- Monotube
- Twintube

Basic design concepts for passenger cars
- Mc Pherson Strut
- Coil over damper
- Damper (stand alone)
- Others (Air-spring-damper-module,..)
DEVELOPMENT OF DAMPER MASS REDUCTION TRENDS TO LIGHTWEIGHT.

As damper design has evolved over the last century, a clear trend towards lightweight damper design can be seen.

It should be noted that trend towards lightweight damper design has been achieved alongside increasing customer requirements, which historically have a negative impact on damper mass.
DEVELOPMENT DAMPER MASS REDUCTION 3 SERIES
MASS ON THE MOVE.

This BMW 3 Series example shows the mass development of a front strut over the last three decades.

- Permanent mass reduction
- General need for change

EVERY GRAM COUNTS, BMW Group, Hubert Strobl, 15/05/2013
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LIGHTWEIGHT DESIGN FOR SHOCK ABSORBERS.

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The current industry standard for shock absorber design in modern passenger cars typically include:

- Technology mainly steel / lightweight steel, partly aluminium technology
- Weight influenced by axle concepts, vehicle mass, loads and requirements
- Average weight range dampers
  - Strut 2.9 .. 4.7 kg
  - Coilover 2.6 .. 3.9 kg
  - Damper 1.5 .. 3.0 kg
Absolute damper weights can not be compared, as they give no feedback about their functional performance.

- A more representative “statistical” measure is required, which will take requirements into account.

- The most straight forward method would be to compare damper mass against axle load (axle load is one of main drivers for damper static and dynamic loads).

- **RDM-factor (Relative Damper Mass)**

RDM = “Body Mass Index” of dampers.

Sheer driving pleasure - made by BMW
HOW TO ACHIEVE LIGHTWEIGHT DAMPER DESIGN

DESIGN DEPENDS ON REQUIREMENTS – THE 5 STEPS

1) Know your requirements / loads

2) Draft best concept

3) Optimise interfaces

4) Refine / optimise design to the limits

5) Validate design (reinforce where required)

Design should be based on requirements “on demand”

“You must not over engineer!”
HOW TO ACHIEVE LIGHTWEIGHT DAMPER DESIGN II
CREATE GOOD BASIS / ENVIRONMENT.

Consider function and interface / package requirements

- Downsizing
  ➔ Smaller valve system, pistons / piston rod diameters

- Length reduction
  ➔ Decrease wheel travel
  ➔ Decrease damper ratio
  ➔ Decrease redundant length (piston height,..)
HOW TO ACHIEVE LIGHTWEIGHT DAMPER DESIGN III
CHOOSE CONCEPT – CHANGE MATERIALS.

Follow basic design principles

- Concept/Concept change
  ➔ Monotube instead of Twintube
  (MINI John Cooper Works GP)

- Substitution of materials
  ➔ Alu instead of steel
  (former BMW 5 and 7 Series, current BMW M3)

  ➔ Plastic instead of metal
  (BMW M3 GTS Spring seat)

Reference: BMW M GmbH
HOW TO ACHIEVE LIGHTWEIGHT DAMPER DESIGN IV
DESIGN FOLLOWS LOAD – UP TO THE LIMITS.

Follow basic design principles

- Load distribution
  ➔ Tailored wall thickness in tubes
  (BMW X3 front, Dynamic Damper Control)

- Remove mass where it is not required
  ➔ Hollow rods
  (BMW 3 Series, front)

- Utilize higher performance materials to their limits
  ➔ High strength steels
  (BMW 3 Series)
HOW TO ACHIEVE LIGHTWEIGHT DAMPER DESIGN: OPTIMISE EVERY DETAIL – LESS IS MORE.

Follow basic design principles

- Detail-optimisation ➔ grams out!
  ➔ Tools: FEM/CAD, calculation (spring seat)

⇒ Design:
- lightweight bumper cap (BMW 3 Series long, CN)
- lightweight cable guide (BMW 7 Series predecessor)

LESS IS MORE!
EVERY GRAM COUNTS.
LIGHTWEIGHT DESIGN FOR SHOCK ABSORBERS.

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EXAMPLES OF LIGHTWEIGHT DAMPER DESIGN
GOOD EXAMPLES FOR LIGHTWEIGHT ON DAMPERS 1

- BMW M3 Coupe
  (material change: steel → alu
  load distribution: tapered damper tube)

- BMW 3 Series DTC
  (material change: steel → aluminum
  load distribution and increased function)

- Damper of DTM-winner 2012
  BMW “Spengler”
EXAMPLES OF LIGHTWEIGHT DAMPER DESIGN
GOOD EXAMPLES FOR LIGHTWEIGHT ON DAMPERS II

- Bicycle damper
  (Material substitution: Metal → CFK)

- Rotation damper
  (Concept change: linear → rotation
  & Integration: bearing = damper)
LIGHTWEIGHT IS FEASIBLE AND ESSENTIAL. LIGHTER IS BETTER - CHALLENGE THE LIMIT.

– Light = Image & Success
  ➔ DTM winner 2012 based on perfect overall package and lightweight dampers

– Light = smaller & smarter
  ➔ More space for customer function / design

– Light = more comfort & customer benefit
  ➔ Less un-sprung mass, reduced loads, higher comfort

– Light = more power/kg & less fuel/mile
  ➔ Sheer driving pleasure, efficient dynamics

– Light = sustainable & responsible
  ➔ CO₂ commitment / legal requirements and environmental/social responsibility

Every gram counts.
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FUTURE TRENDS - COMING SOON
USE WHAT´S KNOWN

- Concept lightweight
  Optimised interfaces and
  Monotubes

- Material lightweight
  Ultra high strength steels
  Increased use of tailored tubes and
  Aluminium

➔ Damper still needs to get lighter (similar to an athlete)
FUTURE TRENDS - THE NEAR FUTURE GO BEYOND - EVERY GRAM COUNTS.

- Material lightweight
  Increased use of aluminium
  Magnesium component parts
  Hybrid parts (steel & alu, steel composite)
  High possibility of utilising alternative materials e.g.
  Plastics and Carbon-fibre reinforced plastics for component parts

- Detail optimisation
  “Nail file”

EVERY GRAM COUNTS.
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