Session 6

Automotive Lighting System

Session Speaker

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Session Objectives

At the end of this session the delegate would have understood

- History and development in automotive lighting
- Different types of optical system light sources used in lighting
- Latest trends in automotive lighting
Session Topics

1. History of Automotive Headlamps
2. Headlamp Design and Styling
3. Headlamp Elements
4. Different Types of Optical Systems
5. Headlamp Leveling System
6. Headlamp Cleaning System
7. Light Source for Headlights
8. Advanced Lighting Technology
9. Pedestrian Friendly Headlamps
10. Signal Lamps
Front End Lighting

- High-beam / low-beam headlamps
- Fog lamps
- Auxiliary driving lamps
- Turn signal lamps
- Parking lamps
- Side-marker lamps and clearance
- Lamp (wide vehicles only)
- Day time running lamps (DRL) (in some countries)

http://www.bosch.com
Headlamps

- Headlamps at the front end of a vehicle, illuminates the road ahead during periods of low visibility, such as night so that driver can make out obstacles ahead
- Identity to the vehicle

http://www.volkswagen.com
Night driving was uncommon at the earliest period of automobiles. The earliest headlamps were introduced in the late 1880s, were fueled by acetylene gas. The first electric headlamps were introduced in 1898 on the Columbia Electric Car from the Electric Vehicle Company (but they were optional).
History of Automotive Headlamps

- After World War 1 electrical illumination was eventually established.
- Form 1904, acetylene lights were offered by a number of manufacturers as standard equipment.
  - Peerless (United States automobile company) made electrical headlamps standard in 1908.
- From 1909, regulations introduced in the German empire required all motor vehicles to be equipped with two front lights.

http://www.bosch.com
History of Automotive Headlamps

• Good visibility at high speed
• Average speeds were on the rise;
  • Land speed record rising from over 105 kph in 1899 to 195 kph in 1906
• Need for a new electric power source
• The main difficulty posed by electrical light was providing the amount of power needed
  • Leads to introduction of generators by Bosch
• Osram (1906) developed tungsten-filament bulb
  • More robust than its predecessor
  • Better able to withstand the vibrations from road irregularities.
History of Automotive Headlamps

Bosch automotive lighting system (1913)

http://www.bosch.com

Introduction to modern electrical system by Cadillac with Delco electrical ignition and lighting system (1912)

The Bosch automotive lighting system (1913)

• Headlights, generator, and regulator.
History of Automotive Headlamps

In 1915 low beam headlamps were introduced by the Guide Lamp Company.

1917 Cadillac revised the electrical system.

- The 1924 Bilux bulb was the first modern unit, having the light for both low and high beams of a headlamp emitting from a single bulb.
- In 1927, the foot-operated dimmer was introduced and would become standard for much of the century.
History of Automotive Headlamps

Chevrolet Master Coupe (1940)

- In 1940 standardized 7 inch round sealed beam headlamp was introduced in United States.
- Asymmetric low beam introduced in 1957, illuminates vehicles own line without dazzling oncoming traffic.

http://www.bosch.com
History of Automotive Headlamps

- Introduction of halogen headlamp for vehicle in Europe by an association of European bulb and headlamp makers (1962).
- Halogen headlamps were prohibited in the United States where non-halogen sealed beam lamps were required until 1978.
History of Automotive Headlamps

- High Intensity Discharge HID systems were introduced in 1991's BMW 7-series.
- European and Japanese markets adopted HID headlamps, but the technology was slow to be followed in North America.
- Lincoln Mark VIII (1996) was the first American effort at HID systems.
Headlamp Design and Styling
Design Elements in Front End
Headlamp Design and Styling

- Quickly creating a different vehicle appearance without extensive body modification

http://www.style4cars.com
Headlamp Design and Styling

www.renault.co.uk

- For special models and facelifts.
Headlamp styling in Europe

- No requirement in Europe for headlamps of standardized size or shape
- That design freedom permitted the development of rectangular headlamps, first used
- Hella for the German Ford Taunus 17M in 1961
Headlamp styling in Europe

- Importance of aerodynamics
- Conventional round lamps covered with aerodynamic glass or polycarbonate covers,
- Jaguar E-Type (1961) and Citroën DS (1968)
Headlamp styling in Europe

- Introduction of halogen bulb in VW beetle (1971) by Hella
- Saab (1971) introduced wash / wiper system for headlights on the model 99
Headlamp styling in Europe

Triumph TR7 (1980)

- Need for smaller headlamps for better aerodynamics
- Introduction of Pop-up headlamps
- In 1986 the DE (Dreiachsiger Elliptischer) reflector headlamps made its first appearance on BMW 7 series
Headlamp styling in Europe

- In 1940, the US government mandated a 7 in round sealed beam headlamp on all automobiles.
- Introduction of Quad headlamps in 1950s
- Four round lamps, rather than two; one high/low and one high-beam 5¾ in. (146 mm) sealed beam on each side
Headlamp styling in Europe

- Concealable stacked headlamps
- Two headlamps on each side were stacked, low beams above high beams.
- Pontiac used this design starting in the 1963 model year.
Headlamp styling in Europe

- Diagonal arrangement
- Triumph Vitesse (1965) and Bentley S Continental used such an arrangement.
Headlamp styling in Europe

- Jaguar E-Type for European market  
  Jaguar E-Type for U.S. market

- Prohibition of protective element in front of headlamps by U.S. government in 1968

- Though it improves the headlamp performance, it affects the aerodynamics adversely
Headlamp styling in Europe

- By 1979, the majority of new cars in the US market were equipped with rectangular lamps.
Headlamp Elements

• Primary elements in headlamp assembly are
• Bulb
• Reflector
• Lens
Types of Headlamp

- Low beam headlamps
- High beam headlamps
- Auxiliary lamps
- Fog lamps
- Work lamps
- Search lamps
- Flash to pass
Front Lens

- ECE regulation granted approval for plastic lenses in 1993
  - Weight reduction
  - Increased design freedom

Since 1998 the ECE-Regulation R48 requires the compensation of vehicle inclination caused by different loading conditions.

The major purpose of this regulation is:

- avoid glaring of oncoming traffic and
- to ensure an optimum range of illumination

www.hella.com
Headlamp leveling System

- Manual Vertical Aim Control
- This type of VAC is required for Halogen headlamps.
- The driver uses a rotary or slide switch to adjust the headlamps according to the tilt of the vehicle.
- For manual leveling, electric motors used as actuators.
- Hydro mechanical system, Vacuum System or electric System

Manual vertical-aim control (principle)
1 Adjustment actuator, 2 Switch.
Headlamp leveling System

• Automatic Vertical Aim Control

• This type of VAC is required for Xenon headlamps.
• Designed for compensate for load variation by lowering or rising the low beam position.
• Changes in the vehicle’s tilt by accelerating or decelerating can be compensated with a dynamic vertical aim control
Headlamp Cleaning System

- Light soiling of lens increase dazzle and reduces the light output.
- Headlamp cleaning system remove the dirt from the lens of main headlamp.

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Headlamp Cleaning System

- Wipe/wash system
  - Similar to that used for windshield
  - Since plastic lenses are too sensitive for this method it is applicable for glass lenses
Headlamp Cleaning System

- High pressure washer system
  - It can be used for both glass and plastic lenses
  - Cleaning effect is due to the cleaning pulse of the water droplets
Front Lens

• High pressure washer system can be:
  • Static nozzle type
  • Telescopic nozzles
• For plastic lens, only non contact water jet are suitable
• Static nozzles are rigidly mounted which are visibly situated on the bumper

Static nozzle
Headlamp Cleaning System

- Telescopic nozzles
Headlamp Cleaning System

- Aerodynamic headlamps with bigger sweep and inclination require telescope system.
- The nozzle holder is hidden, (e.g. inside the bumper and reach the appropriate spraying position by a hydraulic movement)
- In the resting position the nozzles are hidden by a nozzle caps on the bumper.
- The nozzle holder, the nozzle cap and the telescope fixing unit normally are harmonized with the individual car
- Jet are activated in conjunction with windshield washer if the lamps are switched on
Light Source for Headlights

Historical increase in illuminance for motor vehicles

- First electric headlamp
- First low beams
- High and low beams combined in a single unit
- Asymmetric light distribution
- Performance leap with H4 halogen lamps
- Light from the projection lens: DE headlamps
- Today: The revolution: xenon light

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Light Source for Headlights

- Incandescent bulbs
- Incandescent bulbs radiates invisible infrared light along with visible light
- Dual filament bulb, introduced in 1924 permits the generation of low and high beam lights using a single reflector
- Asymmetric low beams were introduced in 1957
- Incandescent bulbs are available for 6, 12, and 24 V applications
Light Source for Headlights

- Halogen Bulbs
- Twice the light output, higher colour temperature and double service life
- Based on the headlamp design, either reflection systems (lamp and reflector) or projection systems (lamp, reflector and projection lens) are used for low and high beam functions.

Halogen projection system

Halogen reflection system
Light Source for Headlights

- Halogen Bulbs
- ECE regulation 37 for single-filament bulbs and ECE Regulation 8 for H4 dual filament bulbs
- H1 for low beams, fog lamps, and high beam
- H2 for auxiliary lamps
- H3 preferred for fog lamps
- H4 for low and high beams using single reflector,
  - Less commonly used for combined fog/high beam units, approved in the US as HB2
## Light Source for Headlights

<table>
<thead>
<tr>
<th>Lamps</th>
<th>Lighting function</th>
<th>Light source type</th>
<th>El. power, luminous flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>High beam Front fog light</td>
<td>Axial filament</td>
<td>55 W, 800 lm</td>
</tr>
<tr>
<td>H3</td>
<td>High beam Front fog light</td>
<td>Transversal filament</td>
<td>55 W, 1,450 lm</td>
</tr>
<tr>
<td>H4</td>
<td>Low beam + high beam</td>
<td>2 x axial filament</td>
<td>60 W/55 W 1,650 lm/1,000 lm</td>
</tr>
<tr>
<td>H7</td>
<td>All headlamp lighting functions</td>
<td>Axial filament</td>
<td>50 W, 1,500 lm</td>
</tr>
<tr>
<td>H8</td>
<td>Front fog light (possibly low beam)</td>
<td>Axial filament</td>
<td>35 W, 800 lm</td>
</tr>
<tr>
<td>H9</td>
<td>High beam</td>
<td>Axial filament</td>
<td>65 W, 2,100 lm</td>
</tr>
<tr>
<td>H11</td>
<td>All headlamp lighting functions</td>
<td>Axial filament</td>
<td>50 W, 1,350 lm</td>
</tr>
<tr>
<td>HB3</td>
<td>High beam</td>
<td>Axial filament</td>
<td>60 W, 1,860 lm</td>
</tr>
<tr>
<td>HB4</td>
<td>Low beam Front fog light</td>
<td>Axial filament</td>
<td>51 W, 1,095 lm</td>
</tr>
<tr>
<td>NDF H13</td>
<td>Low beam High beam</td>
<td>2 x axial filament</td>
<td>75 W/68 W 1,700 lm/1,100 lm</td>
</tr>
</tbody>
</table>
Light Source for Headlights

• Xenon Headlamp
  • Does not have coiled filament
  • Light emits from an electric arc
  • Inside the bulb, xenon gas is mixed with metallic salt and are ignited by 20,000 volts
  • First went into volume production with BMW
Light Source for Headlights

Xenon light

• First generation Xenon lights (D1) had a high UV component
• Second generation Xenon lamps (D1S/D1R and D2S/D2R), an addition glass filter jacket reduces UV radiation
Light Source for Headlights

Xenon light

- Projection systems
  - An electromagnetic actuator is used to move a shield that switches between low beam and high beam
- Reflection system
  - A small movement of the gas-discharge lamp in the reflector produces the switch to high beam (principle or reflection system)
LED System

- LEDs have been used since 1992 as a light source for signaling functions in the rear
- Earlier LEDs were not used in the front because of their low power
Light Source for Headlights

• Design possibilities
Light Source for Headlights

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Light Source for Headlights

- In 2004, more than 20 percent of all fatal accidents occurred between midnight and 6 a.m. – a period that accounts for only 2.4 percent of daily traffic volume, according to the U.S. Federal Department of Transportation.
Advanced Lighting Technology

- AFS incorporates two independent light sources: a high-output halogen projector for the main beam and a secondary row of light emitting diodes (LEDs)
Pedestrian Friendly Headlamps

- Based on vehicle front design, the headlamps are located in or near the impact region of the upper leg, the child head or the lower leg impactors.
- Headlamps must absorb the impact energy in along with the surrounding components.
- Headlamps should not cause additional injuries
Signal Lamps

- Safety brake light
- Indicator light
- Tail light
- Brake light
- Reversing light
- Reflex reflector
- Side marker light

Rear lighting
Historical development of rear-end lighting
Signal lamps

- Used to mark the vehicle extremities, license plate, and to indicate the driver's intentions.
- Directional changes were first signaled on a basis by rotating arrows, hand signals, and later by illustrated semaphores.
Signal lamps

- Turn -signal indicators

- Directional changes and visual warning are signaled by front, center and rear flashing lamps

- Front indicator lights can be integrated separately in the bumper, bodywork, next to the headlamp or in the headlamp.

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Signal lamps

• Turn -signal indicators

Front turn-signal lamps (position, dimensions in mm)

1) less than 2100 mm if vehicle body type prohibits compliance with regulations on maximum height.

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Signal lamps

- Tail lamps
Signal lamps

• Back up lamp
• Back up lamp is hybrid, two functions:
  • Illustrate the road behind the vehicle while reversing
  • Indicate the other traffic the drivers intention to reverse
  • One or two white lamps are approved
  • EEC 77/540, ECE R77, StVZO, (FMVSS/CUR)
Light Source for Signal Lamps

• Halogen Bulb

• First xenon headlights were delivered in 1992 in Germany and US
• Most common because of the advantages in terms of colour (white), energy consumption and intensity
• H6W bulb front marker lamps
LED Technology in Rear Lamps

- LED Technology
- Development of CHMSL using LED in 90s
- The US-spec BMW 3 Series convertible (1992) was the first series production vehicle to have an LED safety brake light
- Introduction to adaptive rear end lamps
Adaptive Rear lamps

- These systems adapt to changing road conditions and different weather situations.

Tail Light Illumination Adaptation

Tail "off"  Tail "Night"  Tail "Day"

Brake Force Display

“Normal" braking  "Strong" braking  "Emergency" Braking
Standards for Vehicle Signal Lamps

- Angle of visibility for direction indicators (ECE /FMVSS 108)
Summary / Conclusion

- History and development in automotive lighting have been discussed.
- Different types of optical system used in automotive lighting have been discussed.
- Latest trends in automotive lighting have been discussed.