ASA Symposium

Advanced Multi-Speed Transmissions and Their Effect on Fuel Economy, Durability, and Reliability

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Transmission Trends

- Maximum fuel economy and performance
  - continuously variable transmissions
  - dual clutch transmissions
  - transmissions with many available gear ratios
- How much has the increase in gearing impacted the vehicle’s overall fuel economy?
- How has the increased gearing affected the reliability and stress of the internal transmission components?
Transmission Trends

• Driving factors
  • Fuel economy
    • CAFE 2025 – 54.5mpg
    • Many available gear ratios
    • Torque converter clutch strategy
      • TCC lockup in most gears
      • High torque transfer/low energy loss
Transmission Trends

• Trend study
  • Published fuel economy data provided by the EPA on vehicles where the only significant change was the automatic transmission
    • General Motors
      • 6L90 vs 8L90
      • 5.3L engine
    • Fiat Chrysler Automobiles
      • 65RFE vs ZF8
      • 5.7L engine
    • Honda
      • 6 speed vs ZF9
      • 3.5L engine
    • Toyota
      • 660 vs 880
      • 3.5L engine
    • Ford
      • 6R60 vs 10R80
      • 3.5L engine
Transmission Trends

• General Motors
  • 6L90 vs 8L90*
    • Fuel economy changes
      • 0% change in city (16 to 16mpg)
      • -5% change in highway (19 to 18mpg)
    • Clutch element cycling
    • Electronics and hydraulic valve activity

* Fueleconomy.gov states these are available options for the Silverado, but the manufacturer’s website doesn’t list a 5.3L engine with an 8-speed transmission. It is possible the lower fuel economy is due to the larger engine size that is typically found with the 8-speed, but this could not be confirmed.
Transmission Trends

- General Motors
  - 6L90 vs 8L90
    - Fuel economy changes
    - **Clutch element cycling**
      - The clutches on the 6-speed averages 1.5 shifts when shifting from 1\textsuperscript{st} to 6\textsuperscript{th} gear
      - The clutches on the 8-speed averages 1.5 shifts when shifting from 1\textsuperscript{st} to 8\textsuperscript{th} gear
    - Electronics and hydraulic valve activity
Transmission Trends

- General Motors
  - 6L90 vs 8L90
    - Fuel economy changes
    - Clutch element cycling
    - Electronics and hydraulic valve activity
      - The activity on the 6-speed averages 1.75 actuations when shifting from 1st to 6th gear
      - The activity on the 8-speed averages 2.0 actuations when shifting from 1st to 8th gear
Transmission Trends

• Fiat Chrysler Automobiles
  • 65RFE vs ZF 8-speed
    • Fuel economy changes
      • 7% change in city (14 to 15mpg)
      • 1% change in highway (20 to 22mpg)
    • Clutch element cycling
    • Electronics and hydraulic valve activity
Transmission Trends

- Fiat Chrysler Automobiles
  - 65RFE vs ZF 8-speed
    - Fuel economy changes
    - **Clutch element cycling**
      - The clutches on the 6-speed averages 1.4 shifts when shifting from 1st to 6th gear
      - The clutches on the 8-speed averages 2.0 shifts when shifting from 1st to 8th gear
    - Electronics and hydraulic valve activity

<table>
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<th>Gear</th>
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Transmission Trends

- Fiat Chrysler Automobiles
  - 65RFE vs ZF 8-speed
    - Fuel economy changes
    - Clutch element cycling
    - Electronics and hydraulic valve activity
      - The activity on the 6-speed averages 1.4 actuations when shifting from 1st to 6th gear
      - The activity on the 8-speed averages 2.0 actuations when shifting from 1st to 8th gear
Transmission Trends

- Honda
  - 5-shaft 6-speed vs. ZF 9-speed
    - Fuel economy changes
      - 5% change in city (19 to 20mpg)
      - 0% change in highway (27 to 27mpg)
    - Clutch element cycling
    - Electronics and hydraulic valve activity
Transmission Trends

• Honda
  • 5-shaft 6-speed vs. ZF 9-speed
    • Fuel economy changes
    • **Clutch element cycling**
      • The clutches on the 6-speed averages 1.0 shifts when shifting from 1\textsuperscript{st} to 6\textsuperscript{th} gear
      • The clutches on the 9-speed averages 2.22 shifts when shifting from 1\textsuperscript{st} to 9\textsuperscript{th} gear
    • Electronics and hydraulic valve activity
Transmission Trends

- Honda
  - 5-shaft 6-speed vs. ZF 9-speed
    - Fuel economy changes
    - Clutch element cycling
  - **Electronics and hydraulic valve activity**
    - The activity on the 6-speed averages 1.7 actuations when shifting from 1st to 6th gear
    - The activity on the 9-speed averages 2.22 actuations when shifting from 1st to 9th gear
Transmission Trends

• Toyota
  • U660 vs U880
    • Fuel economy changes
      • 5% change in city (19 to 20 mpg)
      • 8% change in highway (25 to 27 mpg)
    • Clutch element cycling
    • Electronics and hydraulic valve activity
Transmission Trends

• Toyota
  • U660 vs U880
    • Fuel economy changes
    • **Clutch element cycling**
      • The clutches on the 6-speed averages 1.6 shifts when shifting from 1st to 6th gear
      • The clutches on the 8-speed averages 1.6 shifts when shifting from 1st to 8th gear
    • Electronics and hydraulic valve activity
Transmission Trends

- Toyota
  - U660 vs U880
    - Fuel economy changes
    - Clutch element cycling
    - Electronics and hydraulic valve activity
      - The activity on the 6-speed averages 1.4 actuations when shifting from 1st to 6th gear
      - The activity on the 8-speed averages 1.5 actuations when shifting from 1st to 8th gear
Transmission Trends

- Ford
  - 6R80 vs 10R80
    - Fuel economy changes
      - 6% change in city (17 to 18 mpg)
      - 4% change in highway (24 to 25 mpg)
    - Clutch element cycling
    - Electronics and hydraulic valve activity
Transmission Trends

• **Ford**
  • **6R80 vs 10R80**
    • Fuel economy changes
    • **Clutch element cycling**
      • The clutches on the 6-speed averages 1.5 shifts when shifting from 1st to 6th gear
      • The clutches on the 10-speed averages 2.0 shifts when shifting from 1st to 10th gear
    • Electronics and hydraulic valve activity

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<th>Clutch ID</th>
<th>Forward Clutch (A)</th>
<th>Direct Clutch (B)</th>
<th>Intermediate Clutch (C)</th>
<th>Low/Rev Clutch (D)</th>
<th>Overdrive Clutch (E)</th>
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* TCC operation available in gears 2 through 6, dependent upon throttle position, transmission fluid temp and vehicle speed.
^ D clutch is applied until 3 mph, then it is released.

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<table>
<thead>
<tr>
<th>Gear</th>
<th>A Clutch (1, 2, 3, 4, 5, 6, M1, M2, R)</th>
<th>B Clutch (2, 8, 9, 10, M1, M2, R)</th>
<th>C Clutch (2, 3, 4, 5, 7, 8, 10, M2)</th>
<th>D Clutch (2, 3, 4, 5, 7, 8, 10, M2, R)</th>
<th>E Clutch (4, 5, 6, 7, 8, M1, R)</th>
<th>F Clutch (4, 5, 6, 7, 8, 10, R)</th>
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<td>Ring Gear No. 4 and Planetary No. 1</td>
<td>Sun Gear No. 1 and Sun Gear No. 2 in H direction</td>
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</tbody>
</table>
Transmission Trends

- Ford
  - 6R80 vs 10R80
    - Fuel economy changes
    - Clutch element cycling
    - **Electronics and hydraulic valve activity**
      - The activity on the 6-speed averages 1.75 actuations when shifting from 1st to 6th gear
      - The activity on the 10-speed averages 2.0 actuations when shifting from 1st to 10th gear
Transmission Trends

• Questions?