Measuring and interpreting load spectra in the hydrostatic traction drive of a self-propelled forage harvester

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Dipl.-Ing. agr. M. Heckmann ¹,
Dr.-Ing. M. Gallmeier ²,
Prof. Dr. H. Auernhammer ¹,
Prof. Dr. H. Bernhardt ¹

¹ Agricultural Systems Engineering, Technische Universität München
² Holmer Maschinenbau GmbH, Schierling/Eggmühl
Overview

1 Establishment of continuously variable traction drives (CVTDs) in self-propelled harvesting machines
2 Assembly of measurement equipment and test lead
3 Results of field tests
4 Conclusions
5 Summary
Establishment of CVTDs in self-propelled harvesting machines

- Innovation driven by increased productivity
- First load spectra in 1965
- In 1995 for hydrostatic modules in traction drives
- New investigations necessary because of
  - Increased top speed of 40 km/h
  - Wide spread of two powered axles
  - Direct hydrostatic traction drives

(Delfs, 1965)
Assembly of measurement equipment

Driving direction

1. $\triangle p$ Front axle pump
2. $\triangle p$ Rear axle pump
3. Q Front axle left wheel
4. Q Rear axle right wheel
5. p Pressure level for displacement mode front axle engines
Test lead

- Investigation of in-field and on-road operation during typical conditions with following machine settings:
  - Mode of driving
  - Mode of header guidance
  - Speed over ground
  - Acceleration and deceleration
  - Operations with or without trailer

- Three different levels of aggregation:
  - Illustration of every single test trial
  - Comparison of different machine settings
  - Generation of load spectra
Illustration of single test trial

- Calculated power requirement of complete traction drive
- Wheel torque rear axle right
- Power front axle left wheel
- Power rear axle right wheel
Comparison of different machine settings

Trailer operation: Engine displacement:

- / dashed line: with
- / / solid line: high
- / solid line: without
- / solid line: low

Torque front axle left wheel

Torque rear axle right wheel

Velocity

Power front axle left and rear axle right wheel

Engine displacement:

\[ y = 0.3692x + 1.7152 \quad R^2 = 0.885 \]

\[ y = 0.4905x + 3.9474 \quad R^2 = 0.8881 \]

\[ y = 2.5678x - 2.1741 \quad R^2 = 0.9519 \]

\[ y = 3.7275x + 0.732 \quad R^2 = 0.9464 \]

\[ y = 0.154x + 2.5277 \quad R^2 = 0.4926 \]

\[ y = 0.0666x + 1.5901 \quad R^2 = 0.6721 \]

\[ y = 0.1672x + 0.9208 \quad R^2 = 0.7323 \]

\[ y = 0.0303x + 1.1129 \quad R^2 = 0.2463 \]
Load spectra in-field 4-WD driving mode

- Front axle left wheel
- Rear axle right wheel
Load spectra on-road 2-WD driving mode

Cumulative frequency

Wheel torque M

Wheel torque M

Front axle left wheel

kNm

25
20
15
10
5
0
-5
-10
-15
-20
-25

0.0001
0.001
0.01
0.1
1

Results of field tests

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Load spectra rear axle right wheel

Lines of constant power (ideal state):
- 40 kW
- 30 kW
- 20 kW
- 10 kW
- 5 kW

Wheel torque $M$

Revolution speed

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3 Results of field tests
Conclusions

• Ranking the investigated machine settings on the basis of their relative influence on the power requirements
  – Operations without vs. with trailer $\Rightarrow \approx + 75 \%$
  – Speed over ground $\Rightarrow \approx + 38 \%$
  – Mode of header guidance $\Rightarrow \approx + 24 \%$
  – Mode of driving $\Rightarrow \approx + 10 \%$

• Potential issues for future projects:
  – Optimizing the existing drives
  – Transfer of the results to other self-propelled machinery after standardization
  – Development of alternative drives based on the logged load spectra
Summary

• Logging hydrostatic parameters to generate load spectra for the traction drive of a self-propelled forage harvester

• Examining impacts of different machine settings on the power demand of the traction drive

• Derive load spectra from the complete logged data

• Continue the work at Agricultural Systems Engineering
Thank you very much for your attention!

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Contact: markus.heckmann@wzw.tum.de