

# Traction force control and slip control (1)

- Desired tractive effort is obtained independent of
  - Speed changes
  - Load
  - Disturbances
- Dynamic system – output depends on both the input and the state of the system
- Mix of servo system and control system
- Disturbances
  - Varying line voltage
  - Poor current collection
  - Insufficient adhesion
  - Varying running resistance

# Factors that influence friction in addition to the slip speed

- Weather conditions
- Contamination on the rails (dirt, ice, rust, oil, leaves)
- Vehicle speed
- Condition of tread and track

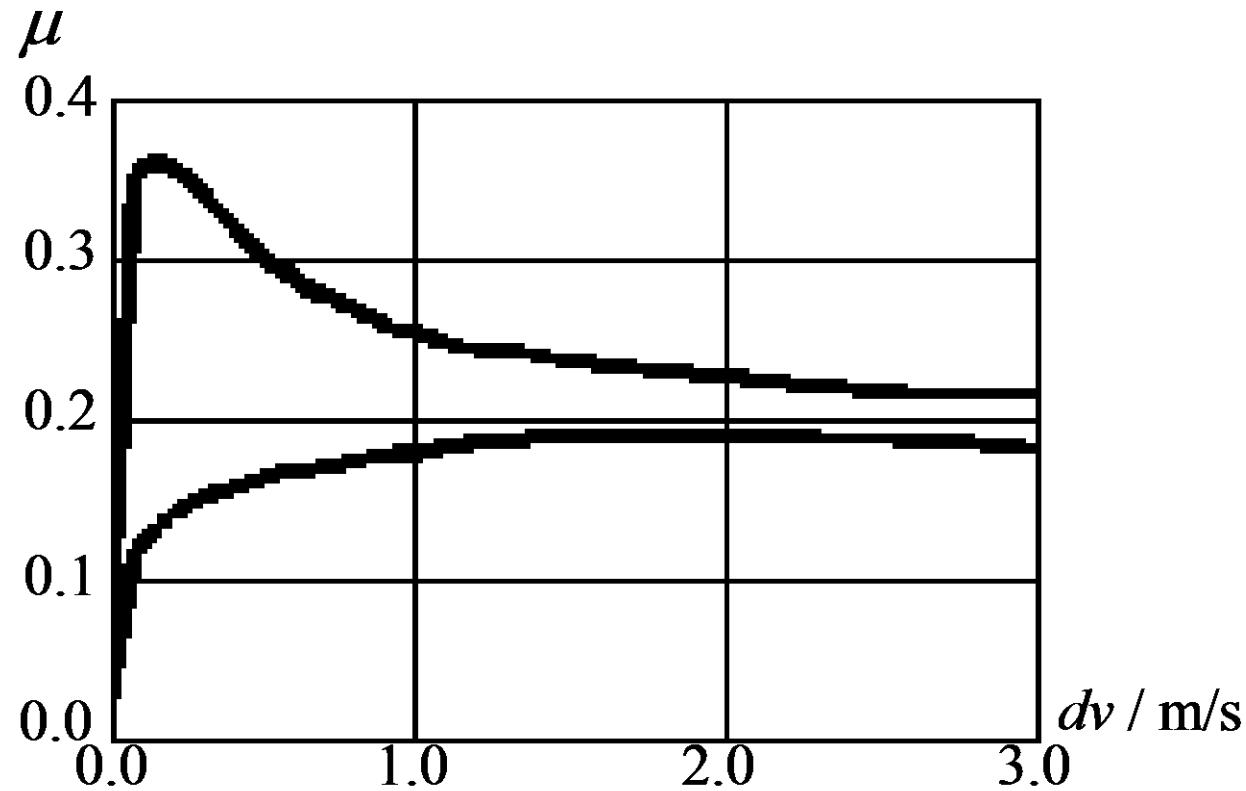
# Traction force control and slip control (2)

- The system contains of two parts
  - Necessary conditions (line voltage, cooling, control voltage etc.)
  - Dynamic control
- Two important characteristics of the system is
  - Accuracy (in measurements)
  - Speed
    - Rise time (depends on the amplitude of the control signal)
    - Settling time
- Converter band width

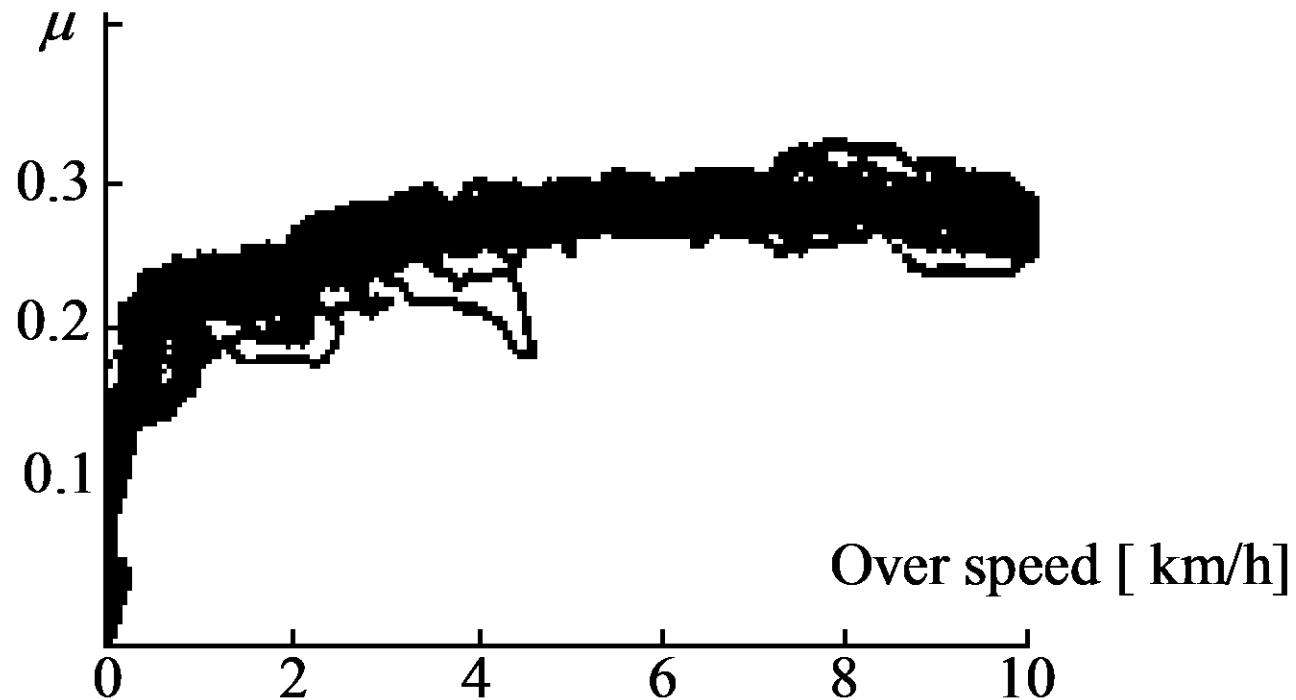
# Traction force control and slip control (3)

- The tractive effort has to be adapted to the adhesion to avoid sliding
- Measuring the peripheral speed of the wheels
  - Varying wheel radius
- Measuring of the slip speed requires estimation of the true speed of the train
  - Difficult with locomotives

# Adhesion curve



# Example of a measured adhesion curve



# Measurement of slip speed

- A measuring wheel or other undriven wheel on the train that does not slip
- Estimation of true speed based on train weight, tractive force and expected acceleration
- Reduction of tractive force on one of the axles to ensure that it does not slip
- Contact-free measurement, e.g. using Doppler radar and correlation measurement.
- GPS

# Track force control and slip speed control

