

TRACEABILITY OF THE CALIBRATION OF TEST CAR FOR ROLL BRAKE TESTER

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Abstract

The calibration of the roll brake tester for trucks has been made general by direct loading of the force transducer. That means to ignore the complete force transmission to rollers, which are in contact to trucks wheel. To be able calibrate exactly the braking force the Finnish institute YTOL has developed a test car to measure direct this braking force. The car has an extra axle with free rotating wheels and braking equipments as well the torque measuring devices. The axle can be moved in vertical position to have the weight maximum 4000 kg on the axle. Raute-MIKES had the task to realise the calibration of this measurement device. The calibration has been made with a 20 kNm reference torque transducer, which is calibrated static by PTB. The calibration of the brake measurement system has been made as dynamic with the speed of braking as static.

Introduction

The test of braking force by wheels in a truck is made with brake roll tester. The axle of car is located on two rolls, which are driven by an electromotor. By braking the wheels the electromotor tries to hold the speed with increasing power. The stator of electromotor is fitted with bearings, which give it freedom to rotate as well. This rotation is hindered by a force transducer, which measured the rotating force, the torque.

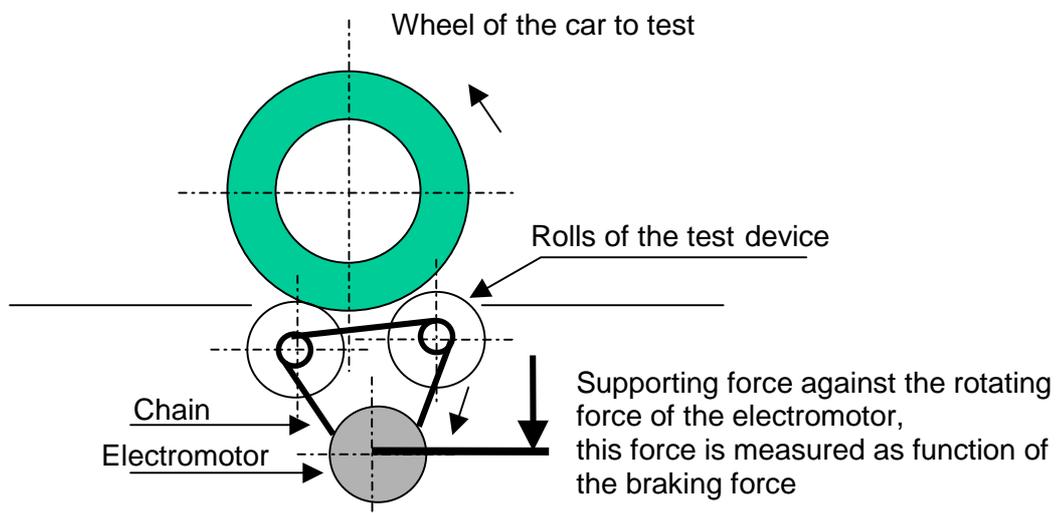


Figure 1. Principe of the roll brake tester

Traditionally testers are calibrated with a beam and mass fixed directly to the force transducers. This method does not take in to account the influence of the mechanical system, bearings and diameter of rolls. Therefore YTOL-institute in Finland has developed calibration trail car to do the calibration dynamically. The trail car has a third axle in middle, figure 1. This axle is hanged free

with bearings and it has possibility to rotate longitudinal around the bearings center. This rotation is hindered with two beams supported on the force transducers, which measure the torque created by braking. It is possible to calibrate the force transducers individually but there are other factors, like length of the beams, friction of the bearings and so on, which are influencing the measurement uncertainty.

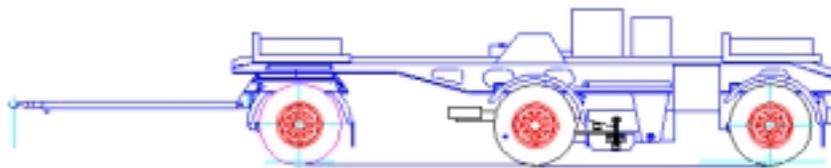


Figure 2. Construction of the test car.



Figure 3. One of the two beams with force transducer.

Traceability

Due the construction of the car, it was not possible to do the calibration in the laboratory. The calibration has been done as field calibration with a reference transducer of 20 kNm.

Dynamic calibration

The aim of the dynamic calibration was to find rotation power of the no loaded axle, rolling friction of the wheels and finally the quasi-static calibration. The rotation of the axle was realized by an

electromotor and gearbox, the power of electromotor was 55 kW. The reference torque transducer was connected between the gearbox and the wheel of trail car, showed in figure 4.



Figure 4. Rotating the wheel by quasi-static calibration.

By rotating the axle in air (wheels did not contact the rollers) the needed torque was ca. 25 ... 35 Nm (the friction of the bearings without vertical load). When the wheels were on the rolls (rolls free rotating) without braking, the measured torque was about 1500 Nm. In normal measurement this torque will be reduced from results by roll brake tester.

Figure 5 shows how the force measurement follows the used torque. The force transducers are measuring the poor braking force, whereas torque transducer is measuring all needed torque. The speed of the wheels is by the measurement 2 km/h or 3 km/h. The measured signal shows that however the measuring is slowly dynamical the change of signal can have high frequency and the amplifier must have good dynamical behaviors. The dynamic character of signals is occurring from the wheel itself, ovality and roughness, and from the surface of the rolls.

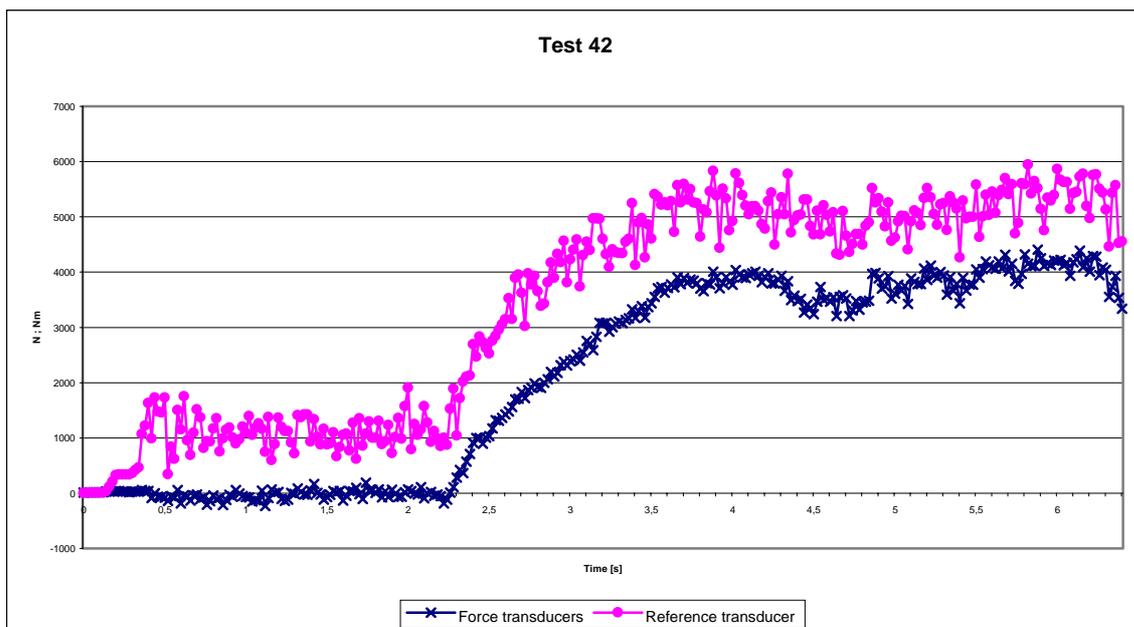


Figure 5. Braking with speed of 2,0 km/h, braking pressure 2 bar, used torque and measured braking force.

Static calibration

By static calibration the reference transducer was located similar on the end of the axle and the torque was build by a beam and a screw, figure 6.



Figure 6. Static calibration.

By loading the torque both signals, torque transducer and force transducers, has been read synchronous with a high accuracy two channel amplifier. Figure 7 shows measured signals. The calibration has been measured several times to get the repeatability. The results show as well the friction of the system, the mechanical reason for that was not investigated. It has been assumed to come from disalignment error of the additional axle bearings.

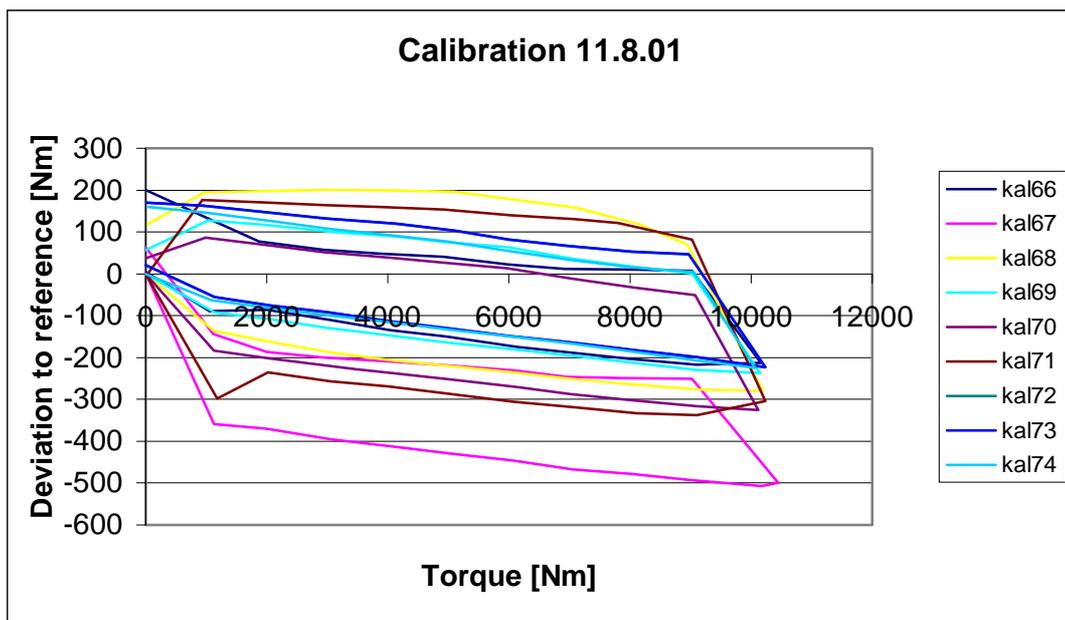


Figure 7. Results of the static calibration of the force measuring systems.

Length of the beams

The length of the beams has been investigated by static calibration separate for each beam. Figures 8 and 9 show the results of these measurements.

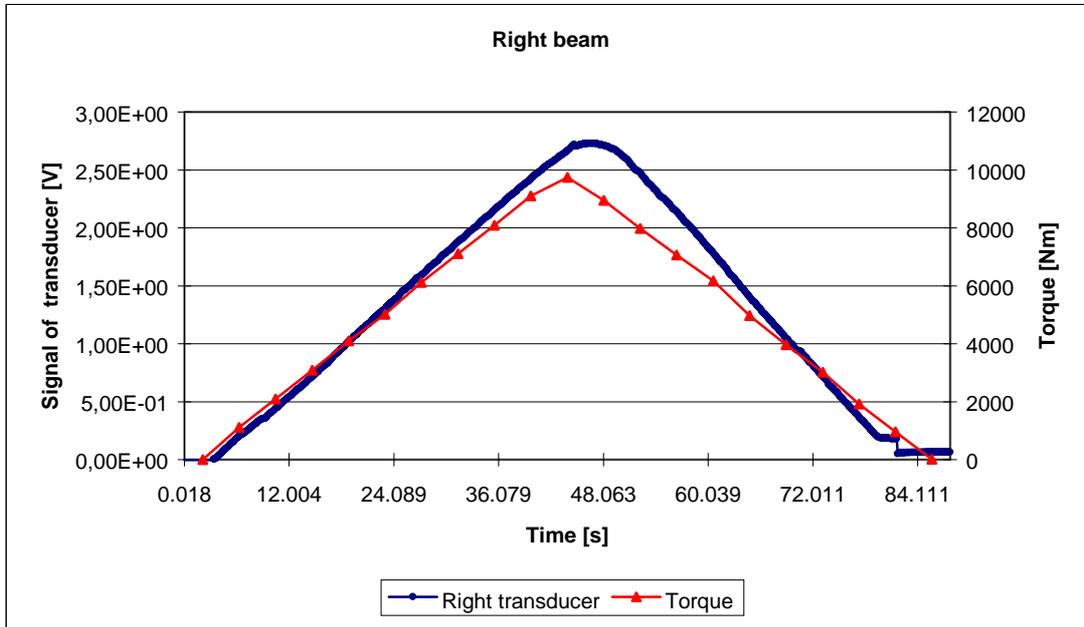


Figure 8. Calibration of the length by right beam.

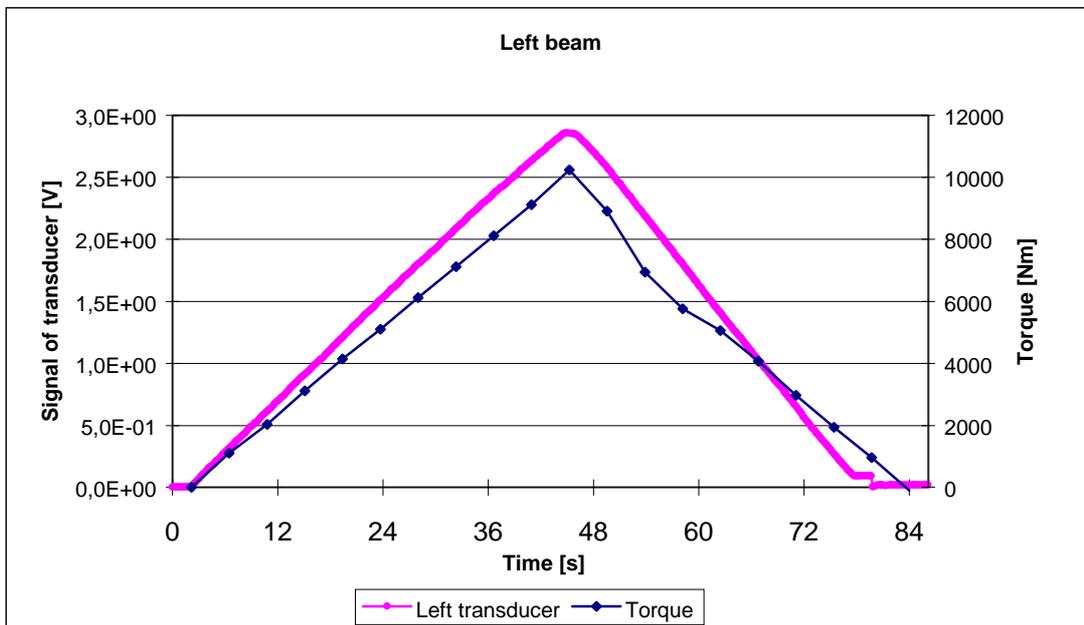


Figure 9. Calibration of the length by left beam.

From results calculated difference of the beam lengths is 7 mm which means relative error of 0,7 %. Mechanical measurement of the beam lengths was not easy, because construction did not have uniform reference points.

Uncertainty of the calibration

The uncertainty of the calibration has been calculated according the guide EA-4/02 "Calculation of the measurement uncertainty" with following uncertainty components.

Uncertainty of the reference transducer

The transducer was calibrated by PTB in the dead weight calibration machine before and after the measurement, time between the calibrations was about 6 months. Calibration gave as uncertainty for the transducer $< 8 \cdot 10^{-5}$ ($k=2$) and shift of the sensitivity $< 1 \cdot 10^{-4}$.

Uncertainty of the amplifier

is based on the calibration certificate of the manufacturer, which is given as value $94 \mu V/V$ ($k=2$). This component has very low influence to the final uncertainty, but it is taken into account by the calculation.

Uncertainty of the force transducers

is based as well on the calibration certificate, the relative value is below 0,1 %, which is not significant compared to the final uncertainty.

Difference in the length by the beams

is taken into account with the value of 0,7 %, the real length is not corrected, which would be as well possible.

Vertical possible deviation between the wheel axel and supporting points (bearings points)

has been calculated from the mechanical dimensions and gives a value up to 100 Nm.

Repeatability of the measurement

has been evaluated from the results of the measurement with the value 150 Nm.

Hysteresis of the equipment

has been evaluated as well from measurements results. In practical measurement the hysteresis has very few influence to the result, because the load is continuously increasing. The uncertainty has been calculated with and without hysteresis. The numerical value of the hysteresis is 300 Nm.

The change of the sensitivity by beams

has been evaluated as well from the calibration results, the value is ca 35 Nm.

| Torque kNm | Uncertainty with hysteresis % | Uncertainty without hysteresis % | Torque kNm | Uncertainty with hysteresis % | Uncertainty without hysteresis % |
|---------------|--|---|---------------|--|---|
| 1 | 20,3 | 10,6 | 6 | 3,9 | 2,7 |
| 2 | 10,3 | 5,6 | 7 | 3,5 | 2,5 |
| 3 | 7,0 | 4,0 | 8 | 3,2 | 2,4 |
| 4 | 5,4 | 3,3 | 9 | 3,0 | 2,3 |
| 5 | 5,0 | 2,9 | 10 | 2,8 | 2,3 |

Figure 10. Uncertainty of the calibration

Summary

The expectation value for the uncertainty of the calibration was 2 ... 3 %, which did not completely achieved. The normal, practical used measurement range is from 5 kNm up to 12 kNm and for this range the reached uncertainty is sufficient. For lower range the characteristic should be improve. The work has shown some weakness in the construction and it will renew for final routine checking of roll brake testers in Finland.

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