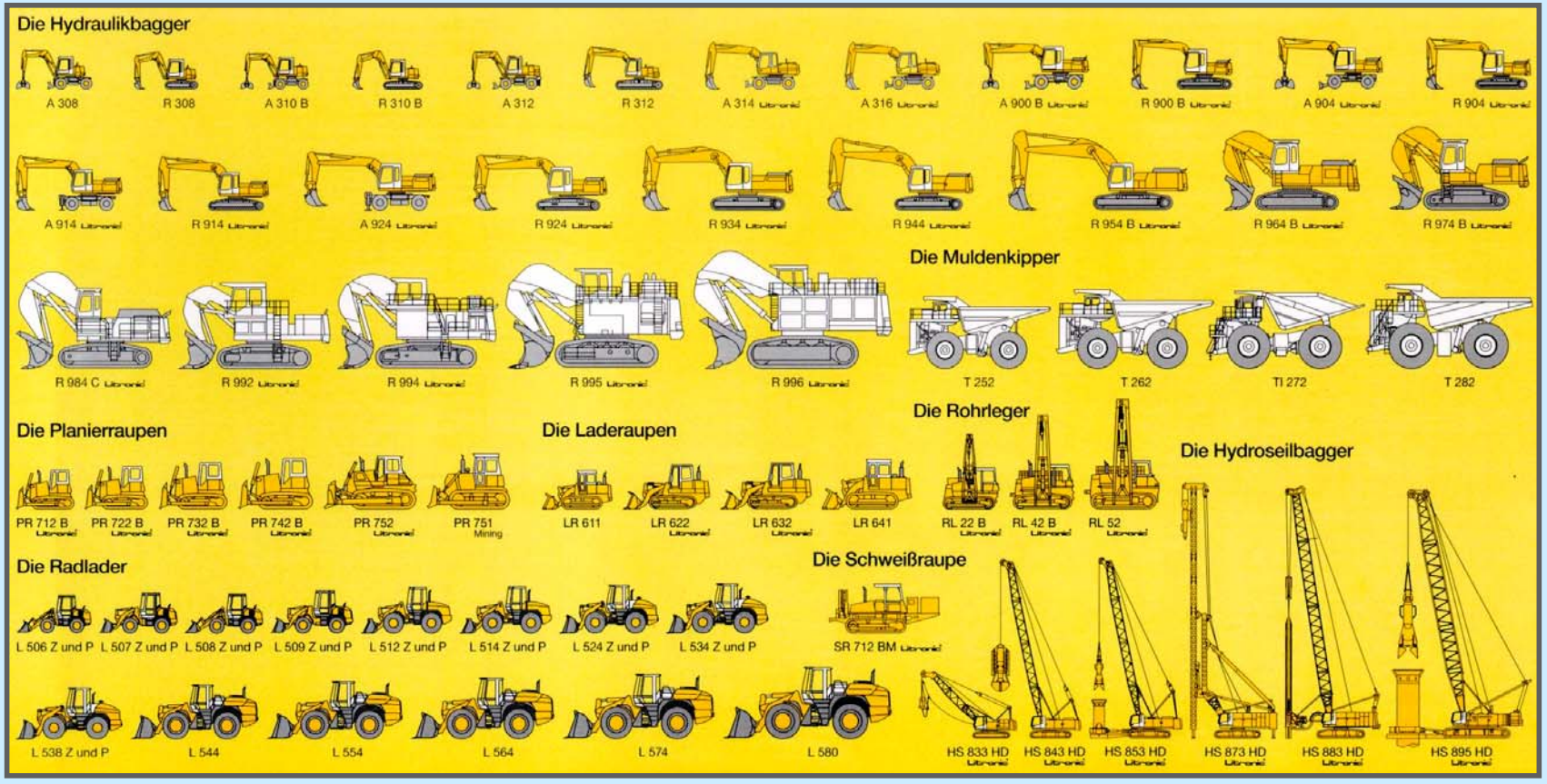
WORLDWIDE SUCESSFULL GROUP OF COMPANIES

LIEBHERR

Products Earth Movement



Plant Liebherr Kirchdorf

Plant Liebherr Kirchdorf

- Biggest Mobile Excavator Manufacturer
- Mobile Excavators from 8 to 67 Tons
- Crawler Shovel Excavators from 10 to 19 Tons
- 1380 Employees
- Till Now about 50,000 Excavators Produced
- Production Area of 300,000 m²
- First Liebherr Production Plant

Products for Earth Movement
Hydraulic Excavator

Products for Transfer of Goods
Hydraulic Excavator

General Equipment Data

- Operating Weight: 30 Tons
- Engine Typ: Liebherr D 924 T-E
- Engine Power: 132 kW at 1950 1/min
- Hydraulic Pump: LPVD 125

  Volume Flow Rate max. 450 l/min

  Operating Pressure max. 320 bar

Mobile Excavator A932

Optimizing of Heat Balance with KULI

Heat Management

What means this regarding to an construction machine?

- Base concept of cooling system for Europe version +40°C and tropical version +50°C ambient temperature (Radiator, oil- und charge air cooler)
- Consideration of mounted attachments e.g. hydraulic hammer
- Compliance with limit value of sound-power level according to regulation 2000/14/EG 11*log P[kW] + 83 = [dB(A)]
- Aggravation of limit value -3dB [LwA] from 2006
- Value for „Umweltengel“ = Limit value minus 5 dB

Mounted Attachments

Hydraulic hammer

Compacting machine

Execution till now

- Placement of many temperature sensors (very time consuming)
- Air flow tests at the cooling system with fogging machine

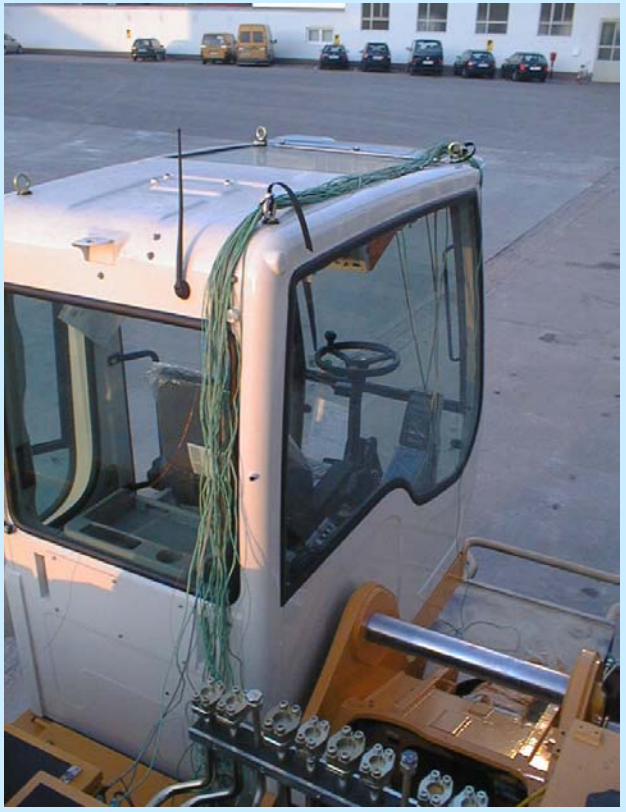
  (In - and outflow and bypass)
- Measurement at typical work:

  - work in gravel pit

  - at smaller machines also overland driving with accompanying vehicle

Approval and Test

Placement of temperature sensors



Air Flow Test with Fogging Machine

Work on Site

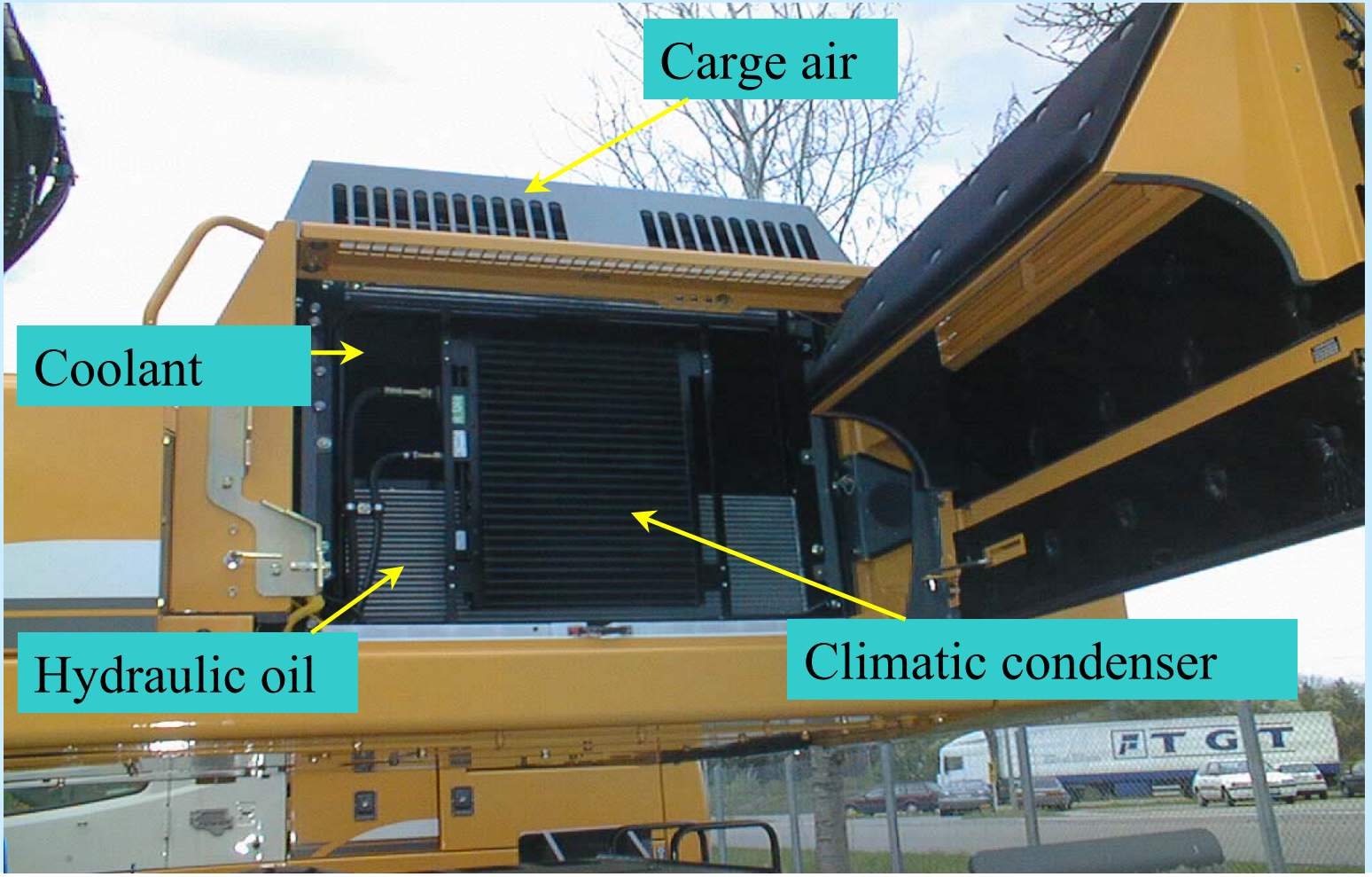
Evaluation of Results

- Evaluation of base concept
- If requirements not reached:

  Variation of type of heat exchangers, depths and placement regarding improvement of heat rejection

- Another measurement after structural adaption
- 3 to 4 iterations, because influence of sound emission has to be considered, which is working against cooling performance

Placement of Cooling System



Finding of Process Optimization because of

- Time- and personnel consuming
- Very long stay of machines in development department
- Measurements dependent on the weather and because of that critical to plan

Solution

- Simulation with calculation model

- Calculation of variants regarding to
  - Improvement of heat rejection
  - Feasibility etc.

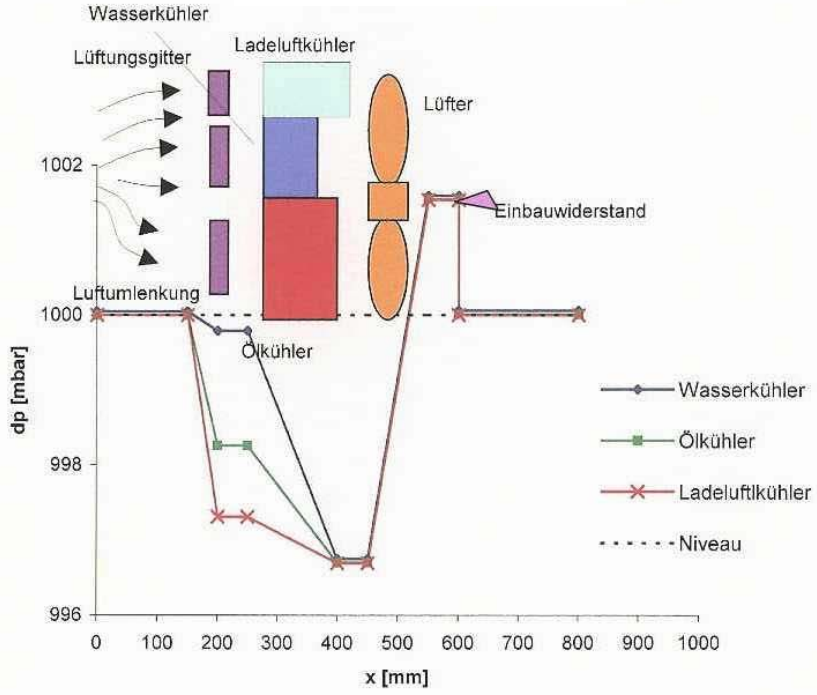
Cooperation with ECS at Excavator A932 to Demonstrate the Feasibility of Simulation with KULI at an Hydraulic Excavator.

- Measurement of excavator operation at 100%
- Modeling of cooling system
- Evaluation of results
- Calculation of variants

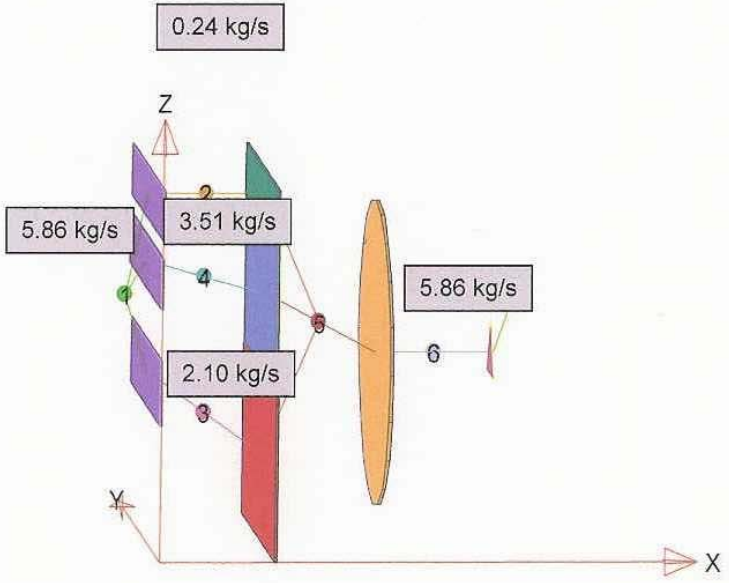
Stationary Operation 100% Engine Load

A932 Stationärer Betrieb 100 % Last (Ist-Stand)

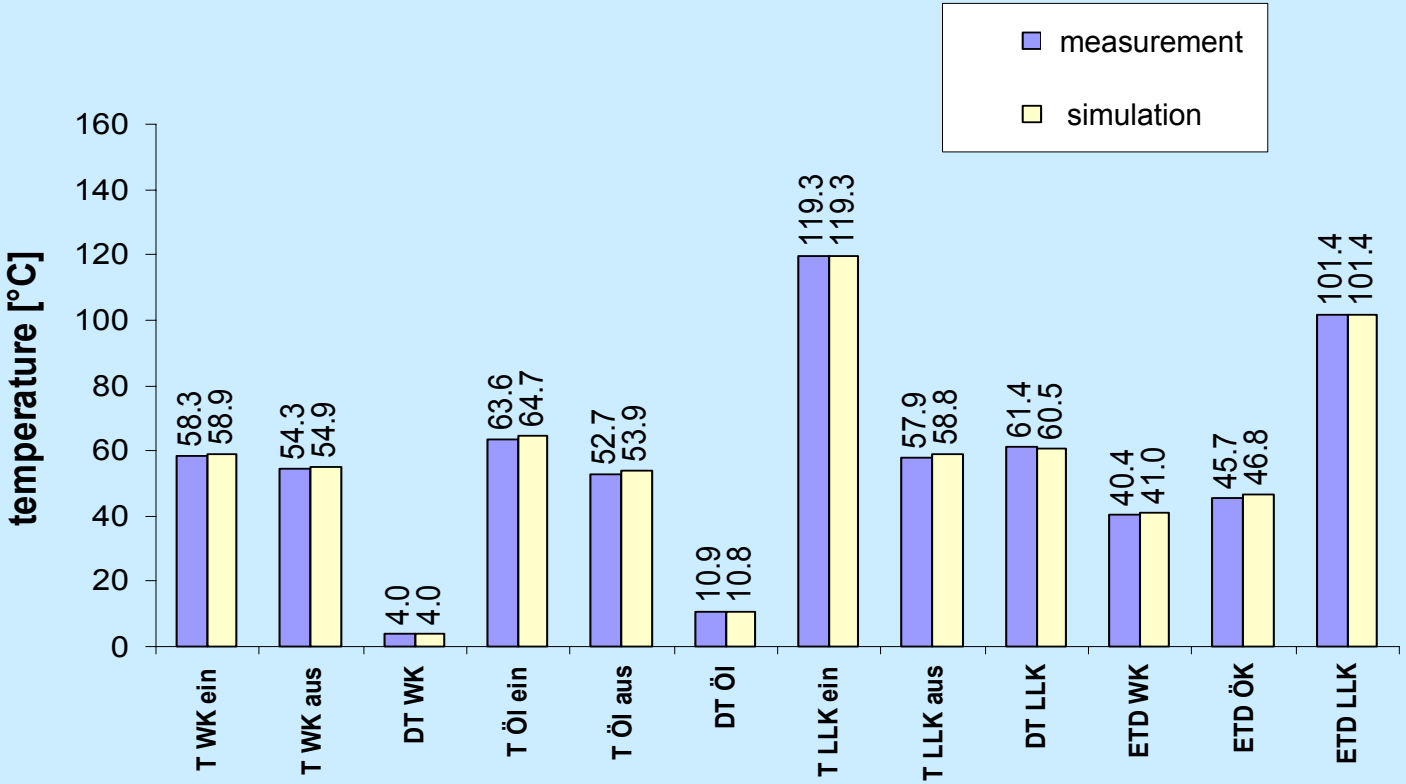
air path pressure loss



cooling air mass flow



Comparison of Measurement and Simulation Excavator Operation



Evaluation

- Good correlation of simulation and measurement
- Intercooler is not fullfilling the requirements of +50°C after intercooler at ambient of +25°C
- Enlargement of intercooler and air flow required

Overview
Variants of Simulation - Intercooler

Variant 1	Intercooler enlarged
Variants 2 + 3	higher fan speeds
Variant 4	Intercooler enlarged and higher fan speeds
Variant 5	Climatic condenser considered
Variant 6	Reduction of charge air inlet temperature
Variant 7	Placement of intercooler below radiator
Variant 8	Placement of charge air precooler
Variant 9	Placement of charge air precooler, same size of package
Variant 10	Simulation of variant 9 to T_{amb} = 45°C

Actions taken

- A new air flow optimized fan shroud has enlarged the air stream and fullfilled the required performance enlargement of the intercooler predicted by KULI simulation

old fan shroud

air flow optimized shroud

Advantages of a Validated Simulation Model

- Only one base measurement for calibration required.
- Variants calculated with KULI regarding improvements and feasibility.
- Influences visible for designers !
- Experience saved not only in the „mind“ of the designers, but with calculation method and KULI model for applications in the future documentated.

Conclusions

- Advantages with Simulation for the Process in Modern Heat Management.
- KULI is a useful Tool for Development and Design.
- Consideration of Sound Emission may be a useful Feature in KULI for the Future.

Thanks for your attention !

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