Improvement of hydraulic control quality for deep drawing presses through retrofit

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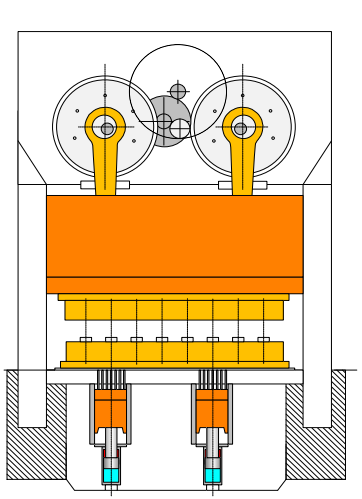
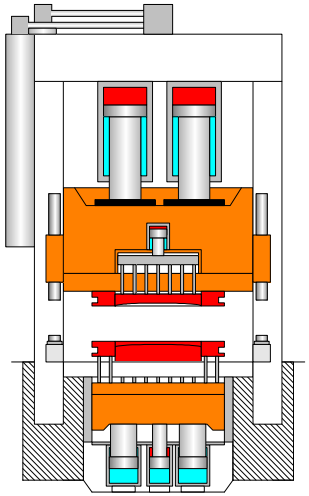
TRsystems GmbH





Outline

1. Introduction
2. Tasks and Machines
3. Solution
4. Results
5. Conclusion

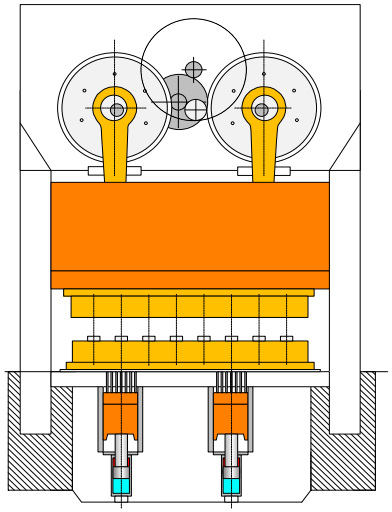
Source: Drive Automotive Industries of America Inc.

Introduction

- retrofit for presses every 10-15 years (electrical)
- some machines have hydraulic closed loop control system (die cushions (DC), ram cushions, hydraulic ram)
  - most machine manufactures use “of the rack” control system
  - special applications need special engineered solutions
- approach by TRsystems is a tailored control solution

Arisa S-4-1600-470-230 LDE

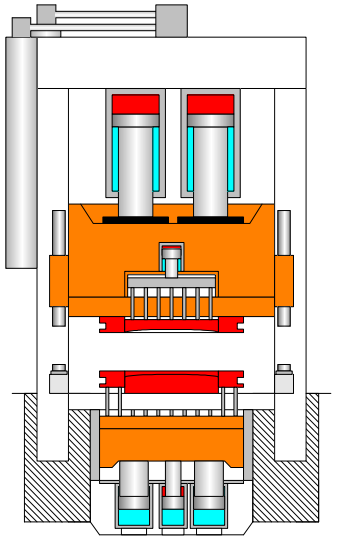
- mechanical transfer press with Link-Drive engine
- 10 separate hydraulic die cushions
- 2 servo valves per cushion
- 3-chamber cylinder for every cushion



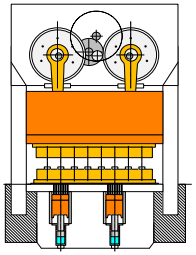
Year of manufacture	2005
Ram (force, stroke)	16.000 kN, 600 mm
Stroke speed	8 – 30 1/min.
Cushion (force, stroke)	600 kN, 200 mm

MW ZE2100.45.2.2

- hydraulic tryout press with MultiCurve-technology
- 4 separate ram cylinders
- accumulator drive for forming stroke
- 8 separate pressure cylinders for die cushion

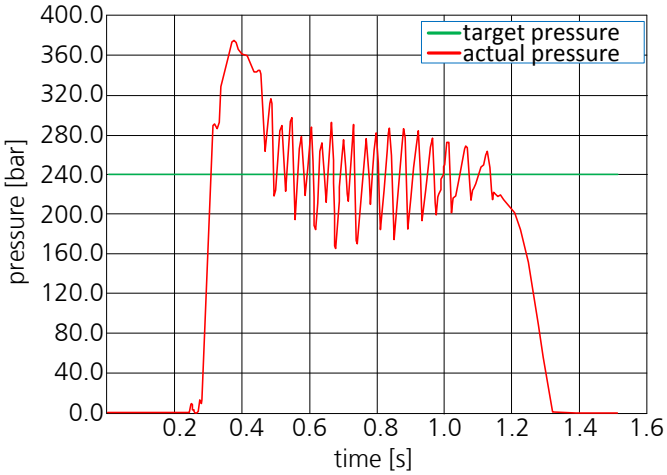


Year of manufacture	2006
Ram (force, stroke)	21.000 kN, 1500 mm
Speed (pressing, rapid down)	500 mm/s, 350 mm/s
Cushion (force, stroke)	6.000 kN, 350 mm



Task for the retrofit

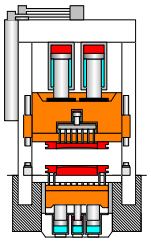
- electrical retrofit of all 10 cushions
- hydraulic remains untouched
- closed loop control for
  - DC pressure and positioning function



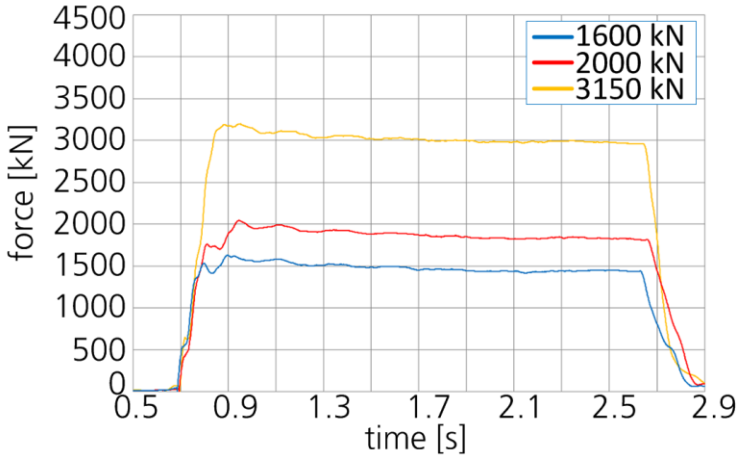
Before retrofit

- heavy pressure overshoots and permanent oscillations
- no consistent component quality

Task for the retrofit



- electrical retrofit of whole machine
- new servo valves for all DC pressure cyl.
- closed loop control for
  - DC pressure and positioning function
  - ram pressure, velocity and parallelism function

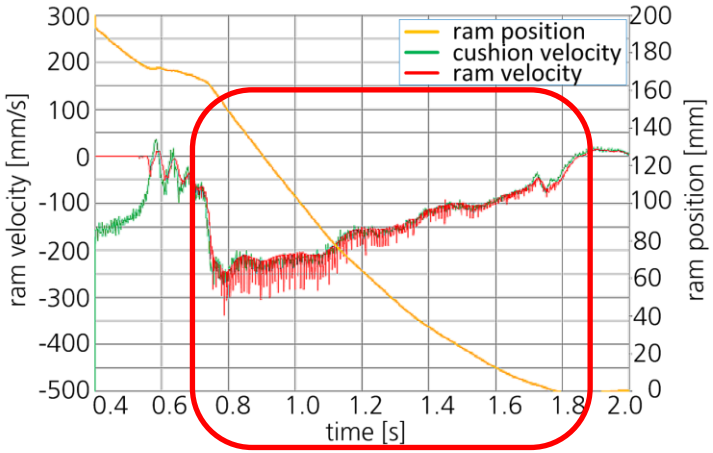


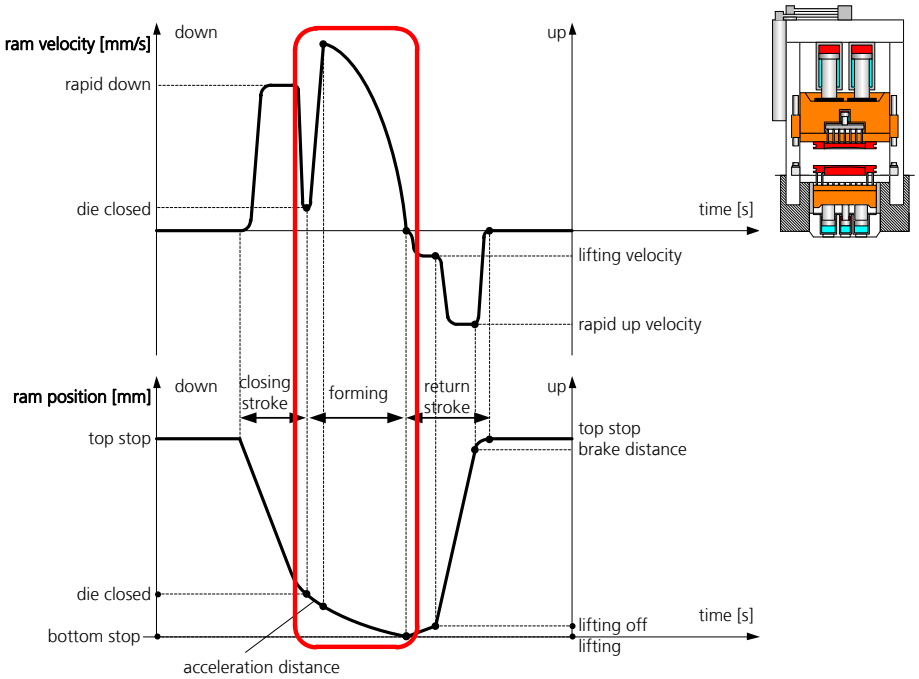
Before retrofit

- no constant DC forces, esp. for higher die speeds
- fluctuations within ram's velocity control

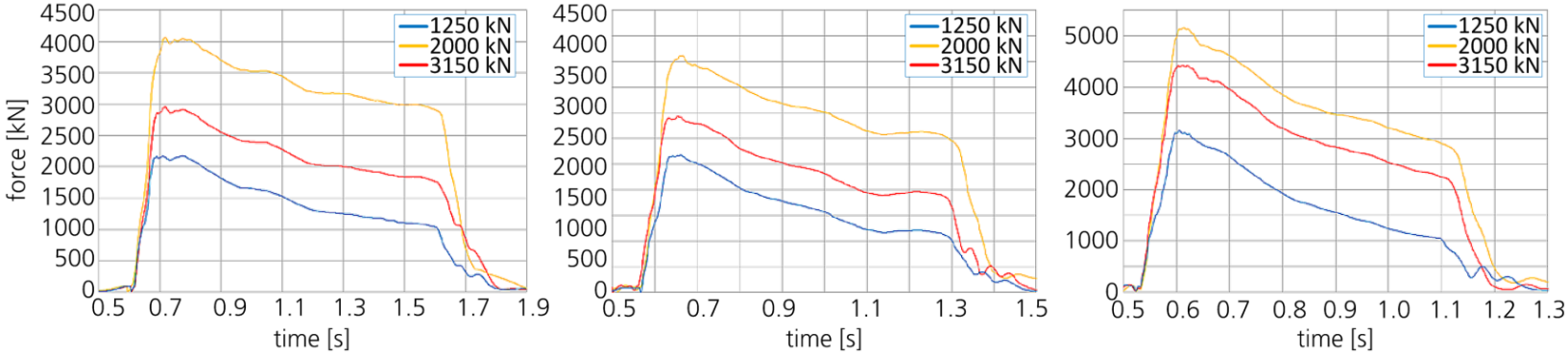
Ram velocity control

- trajectory should look like trajectory of a mechanical press

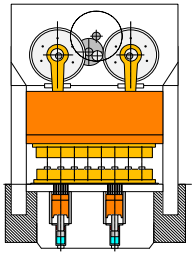




DC pressure control

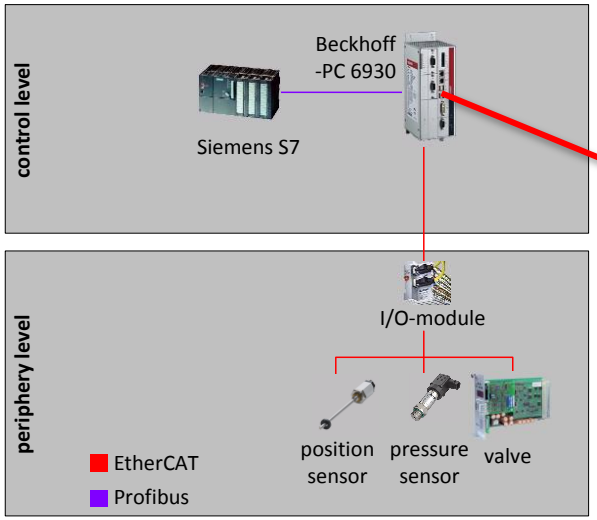


Solution

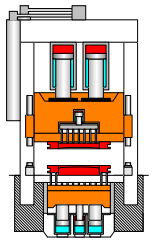


Hardware

- existing control system replaced by Beckhoff IPC
- communication between S7 (840D) and Beckhoff via Profibus DP/DP
- 1 IPC controls all 10 die cushions
- EtherCAT I/O-modules with 16 bit resolution for analogue inputs and outputs

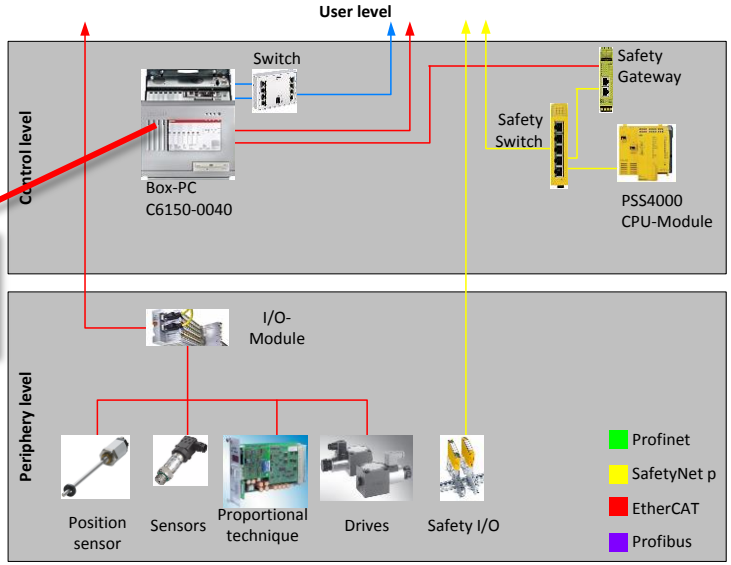


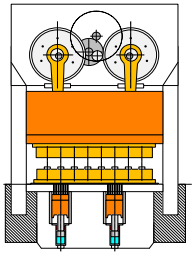
- 125 µs cycle time
- real-time capable

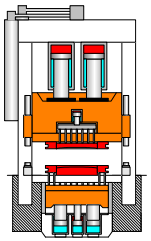


Hardware

- existing Beckhoff control system renewed
- new servo valves for DC pressure function (from 40 Hz to 50 Hz frequency)
- EtherCAT I/O-modules
- new motion sensors for ram‘s parallelism and velocity control





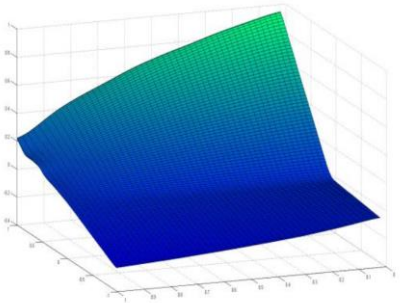


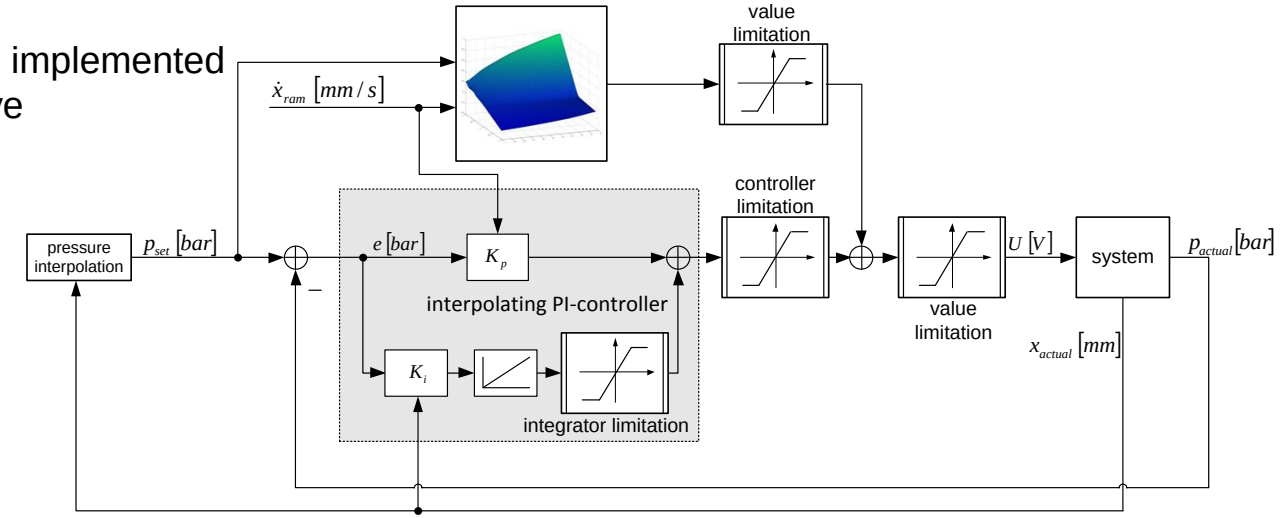
Software

- real-time extension Beckhoff TwinCAT (PLC, visualization and closed loop control)
- control algorithms are written in C++ and executed in ring 0 (kernel mode)
- control algorithms include
  - cam gear, trajectory generation, pressure-/position-/velocity-/parallelism-control…

DC pressure control

- PI-controller (10% of sum signal) and model based feed forward control (90% of sum signal)
- feed forward control is implemented as a 3-dimensionl valve characteristic

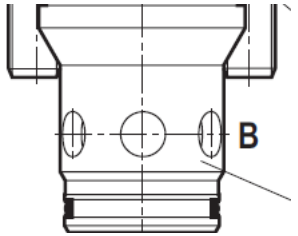


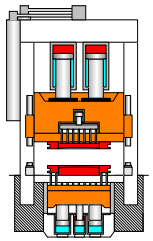


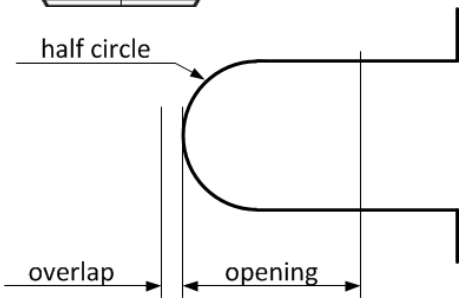
Ram velocity control

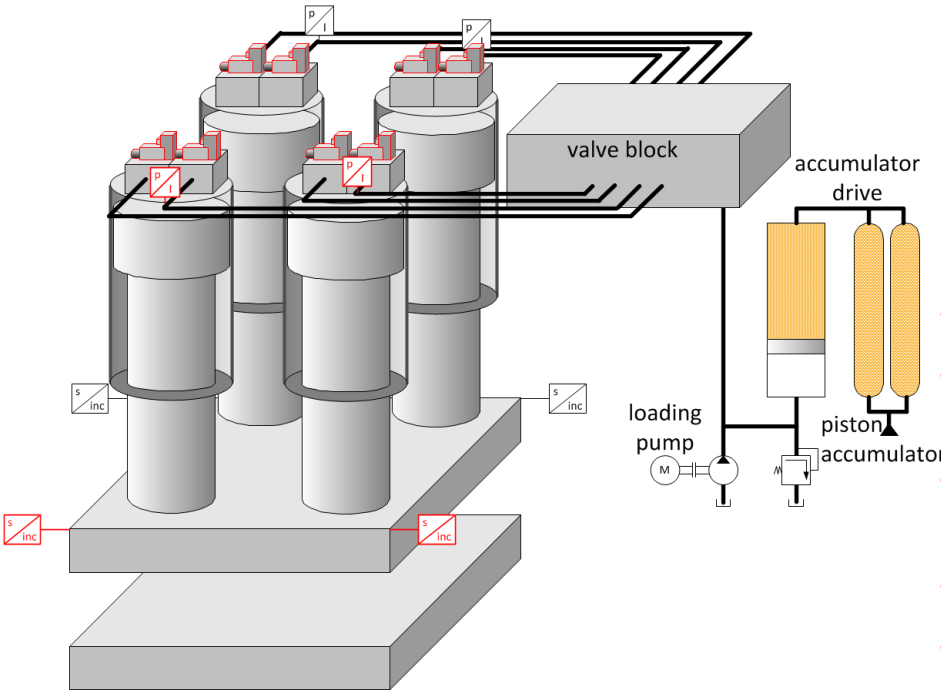
- trajectory generation (5th order, jolt-free)
- velocity control consists of PI-controller and model based feed forward control
- feed forward control was optimized via implementing valve‘s opening profile (servo cartridge Rexroth 2WRCE)

Source: Bosch-Rexroth



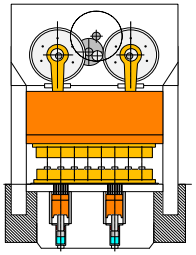






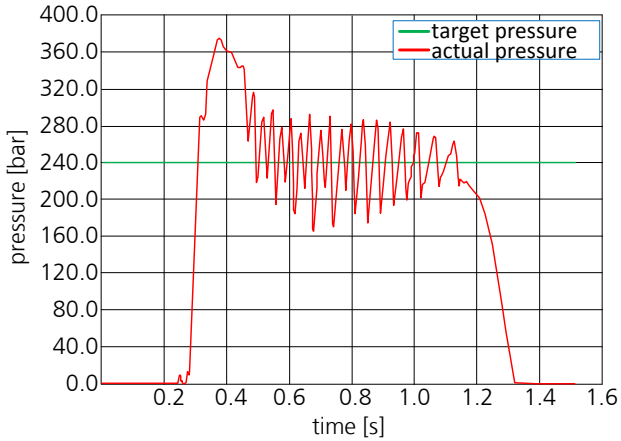
Ram parallelism control

- 4 position signal (every cylinder has its own sensor)
- position differences (tilting) are converted in tilting moments around x- and y-axis
- tilting moments are converted in resulting forces at cylinder center
- target value is 0.0 kN in order to eliminate tilting
- no interference between position-/velocity control and parallelism control

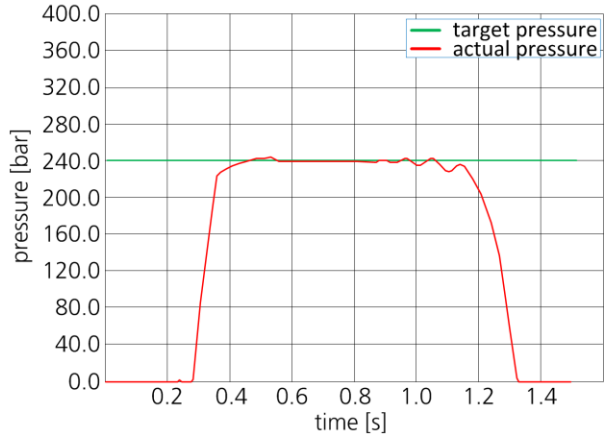


DC pressure control

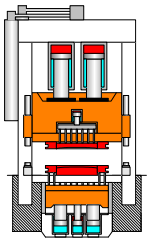
- before retrofit



- after retrofit



Ram velocity control



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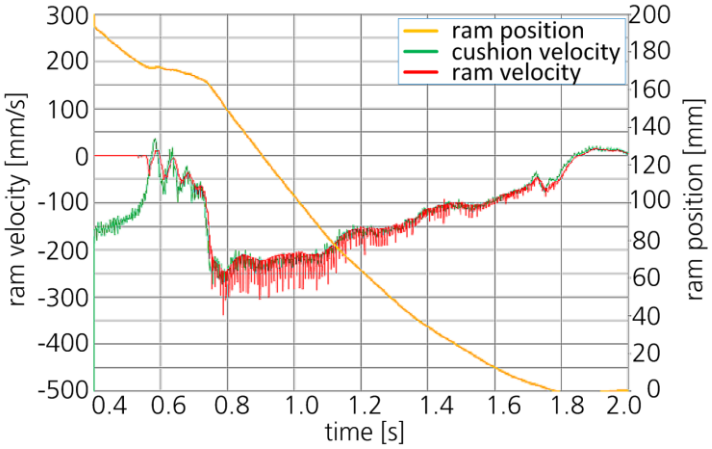
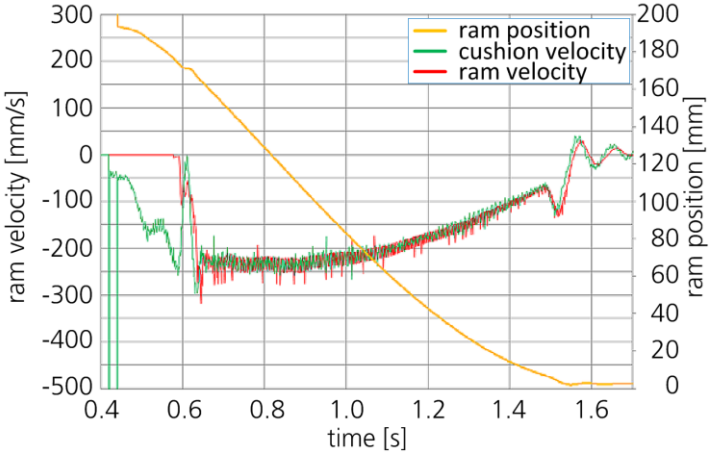
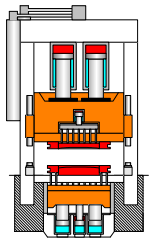


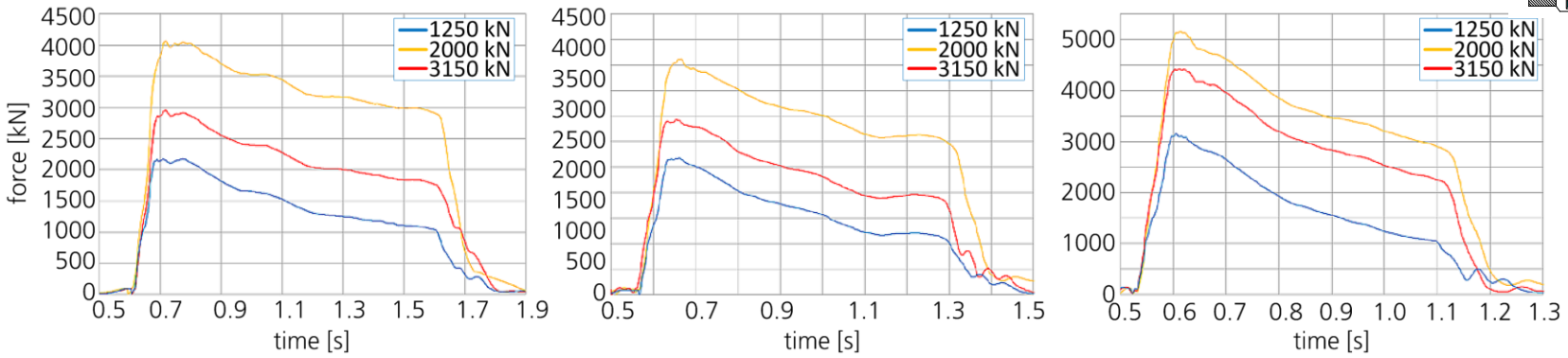
- after retrofit



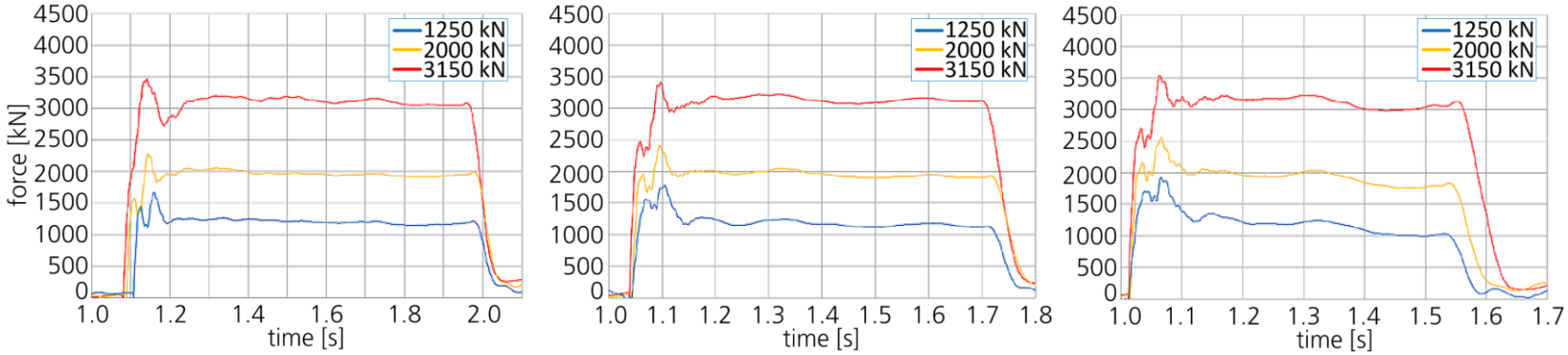


DC pressure control

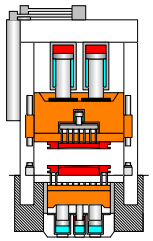
- before retrofit

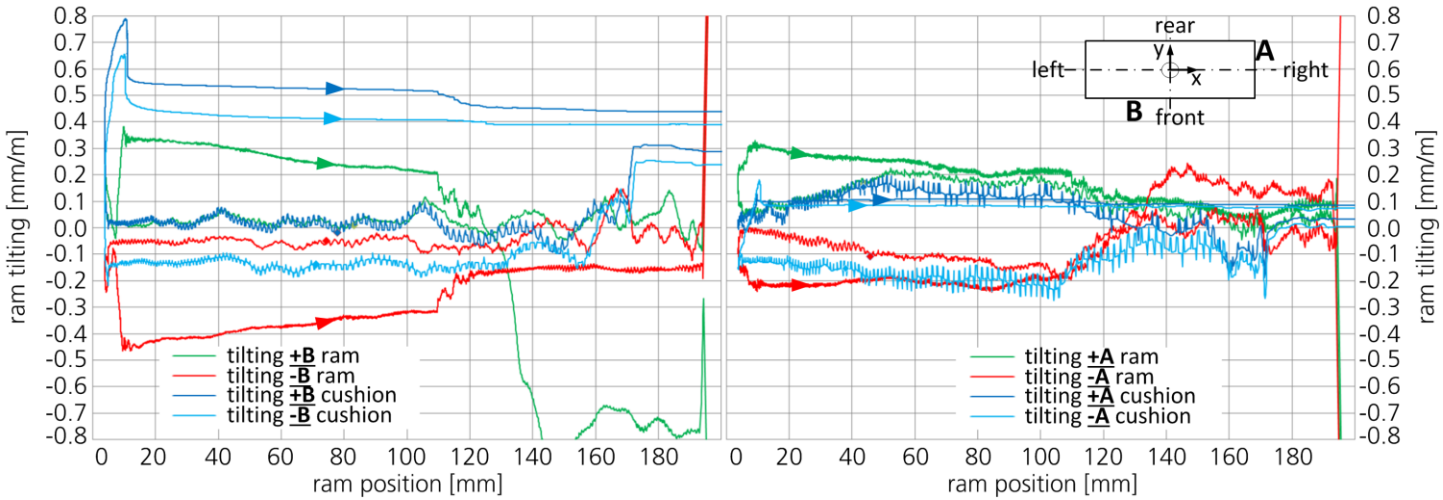


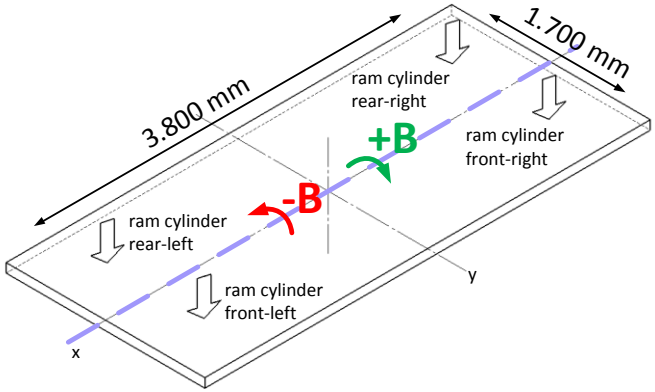
- after retrofit

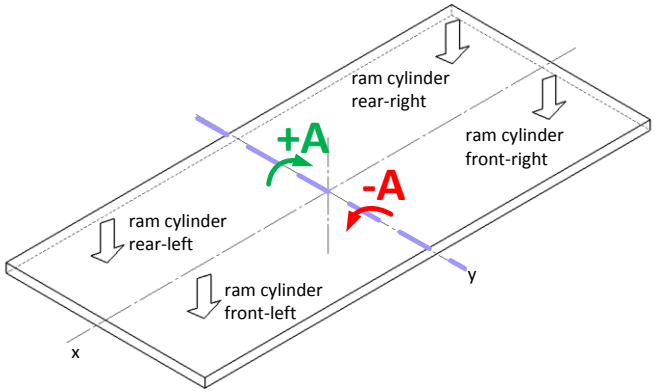


Ram parallelism control









Conclusion

Conclusion

- retrofit has led to enormous enhancement of closed loop control quality
- quality improvement achieved by changes in hardware
  - new servo valves
  - fast and real-time control systems
- model based control algorithms led to new level of stability
- consistent component quality ensured

Outlook

- self-optimizing and self-adjusting control algorithms
  - reducing commissioning time
  - condition monitoring
  - compensation of wear
- using of faster IPCs and servo valves

Research project

adaptive control