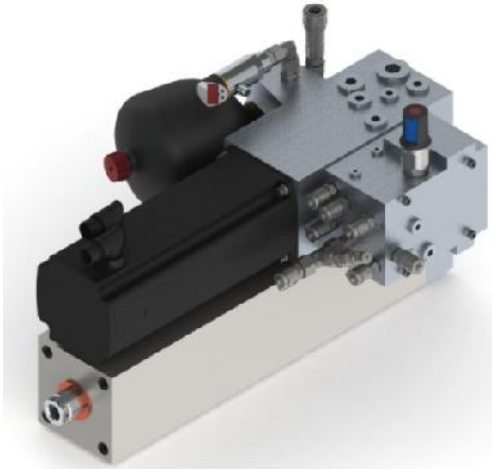
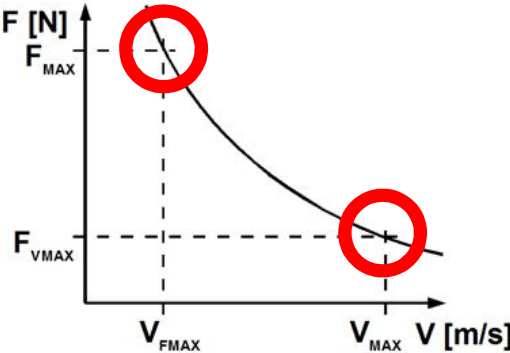




# On Adaptive Electrohydrostatic Actuators

Brahmer, Bert



- 
- 1 EHA - Introduction
  - 2 CLSP – Adaptive Light Weight EHA
  - 3 PDSC – Adaptive Heavy Press EHA
  - 4 Mobile Service Unit
  - 5 Conclusion

## Time Machine

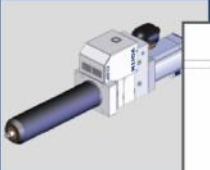
8:ifk Internationales Fluidtechnisches Kolloquium  
 VOITH  
 Voith Turbo H+L Hydraulic GmbH/CO. KG

CLDP - Hybrid Drive using Servo Pump in Closed Loop

Speaker: Bert Brahmer  
 Date: 2012-03-28

Outline:

- 1 Introduction
- 2 Background
- 3 Design
- 4 Control Loop
- 5 Performance
- 6 Examples
- 7 Pressure Fluid
- 8 Conclusion



Looking back to ifk 2012

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Design

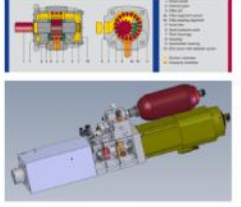
Implementation of Differential Pump

Internal gear pump:

- high efficiency due to axial and radial pressure compensation
- low pulsation
- low noise
- proven for decades

Differential pump:

- Requirement for compact design
- high integration by using „cartridge“



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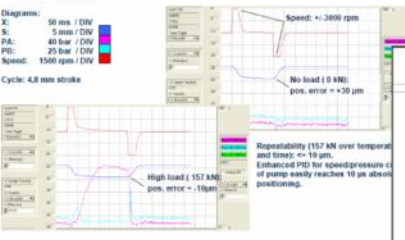
Performance

Test Results

Diagrams:

- X: 50 ms / DIV
- S: 5 mm / DIV
- PA: 40 bar / DIV
- PB: 25 bar / DIV
- Speed: 1500 rpm / DIV

Cycle: 4.8 mm stroke



Speed: +/-3000 rpm  
 No load (0 kN): pos. error = +30 µm  
 High load (157 kN): pos. error = -10µm  
 Repeatability (157 kN over temporal and time): <= 10 µm.  
 Enhanced ISO for speed/pressure c of pump easily reaches 10 µm absolute positioning.

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Examples

Design Examples

Modular design (standard):

- Motor/Pump/Valve unit
- Interface plate
- Cylinder

Options:

- Separation of cylinder
- Very big units
- „Embedded“ cylinder mounting, limited space

straight  
 right angle  
 folded

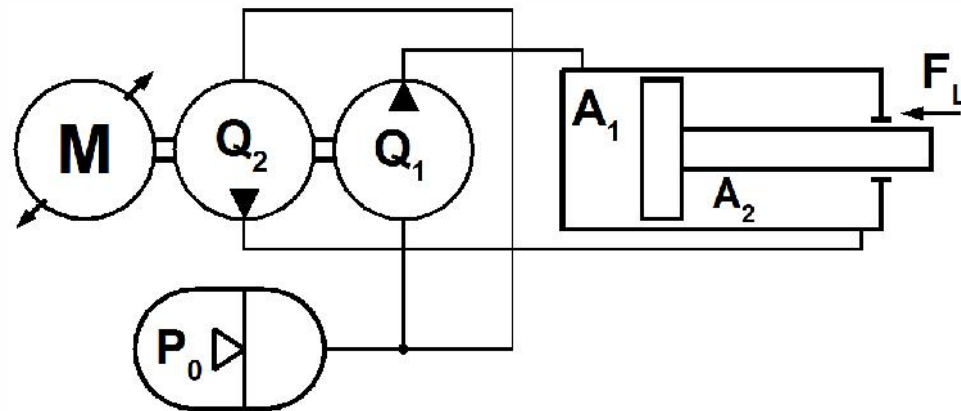
Cylinder-separate mounting  
 Double axis (bending)



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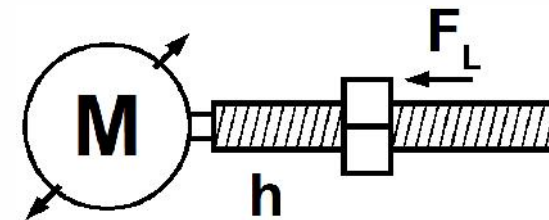
## Operating principle of EHA

Differential cylinder and “differential” pump



$$h_{EHA} = \frac{Q_1}{A_1} = \frac{Q_2}{A_2}$$

Spindle drive



$$V_{LIN} = \frac{\omega_{MOT}}{2 * \pi} * h_{MEC}$$

$$F_{LIN} = h_{MEC} * 2 * \pi$$

## Benefits of EHAs

**Compactness**

no visible powerpack, pipes, hoses

**Power on demand**

no idle consumption in powerpack

**Power efficiency**

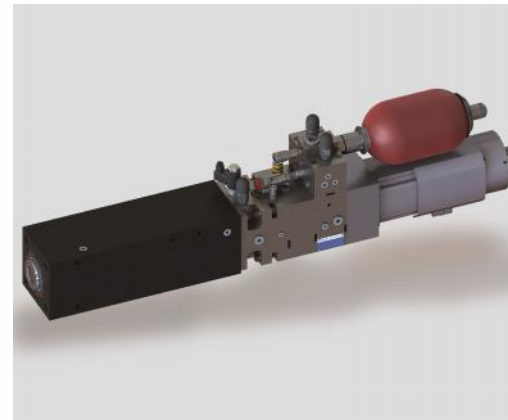
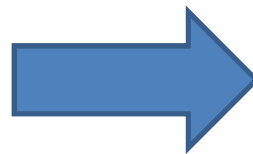
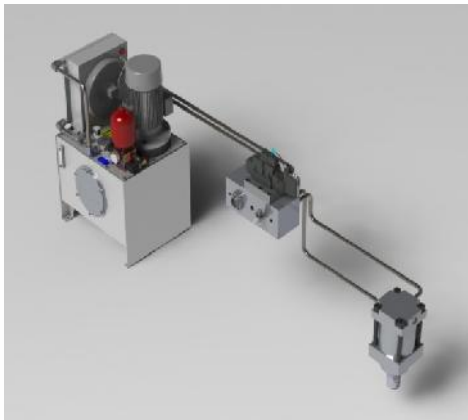
no throttling losses in servo valves

**Ruggedness**

easy to protect against overload

**Safety**

implemented easily with logic valves



## Dimensioning

Requirements (speed, force) defined by particular machine cycle.

Production equipment: a) feed operation → high speed, low force  
b) material processing → low speed, high force

Examples: Bending, forming, riveting, cutting, punching



<http://www.pragmaconindia.com>



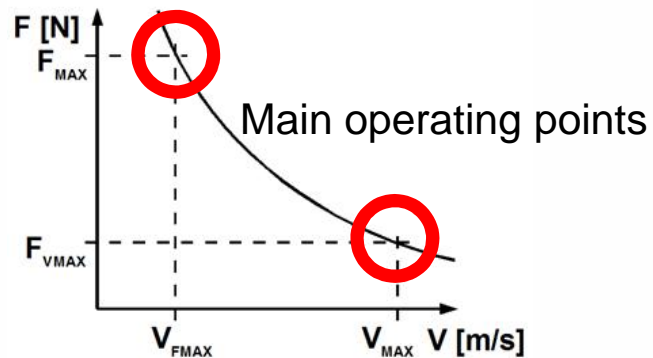
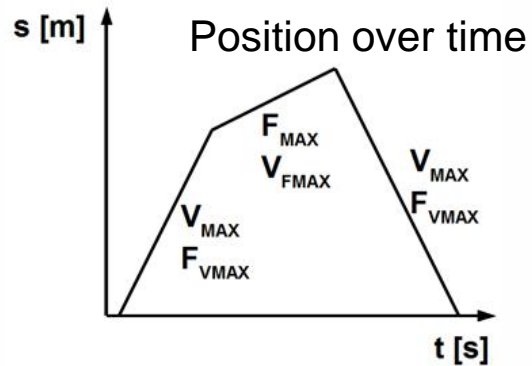
<http://www.jfycnc.com>



<https://automotivemanufacturing solutions.com>

## Dimensioning

Typical work cycle



We need two motors in one:

- low speed and high torque
- high speed and low torque

High torque  $\Rightarrow$  high inertia

High torque  $\Rightarrow$  high current, big inverter

Approach:

Move operating point  $F_{MAX}$  into  $F_{VMAX}$

Use smaller motor, inverter.

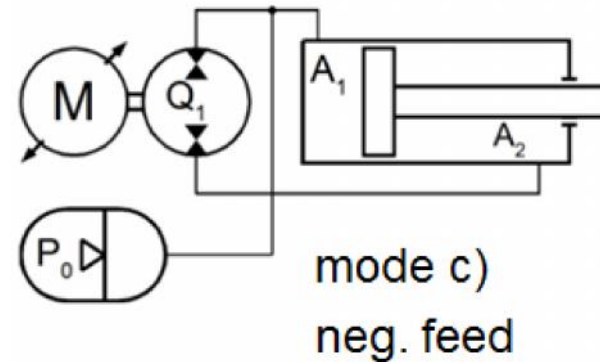
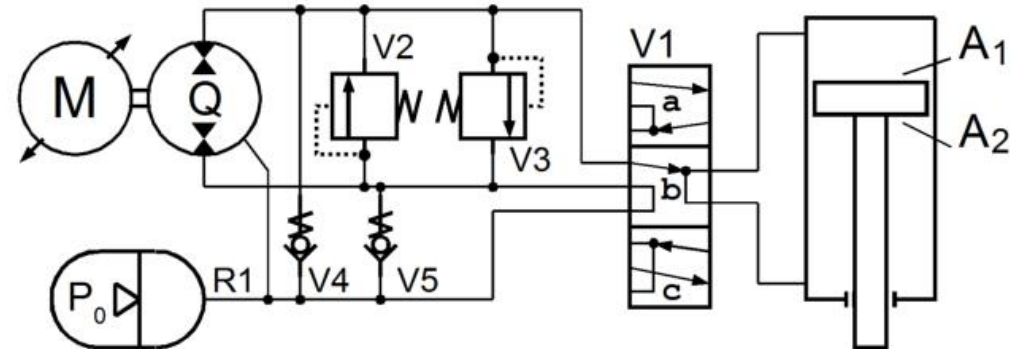
Implementation:

Use adaptive pitch:  $h = \frac{Q}{A}$

### Target Application

- a) low moving mass.
  - b) discontinuous speed during adaption.
  - c) continuous process force.
- + riveting
  - + cutting (low weight tool)
  - + bending (low weight tool)
  - punching (c)
  - heavy press machine (a)

### Function Principle

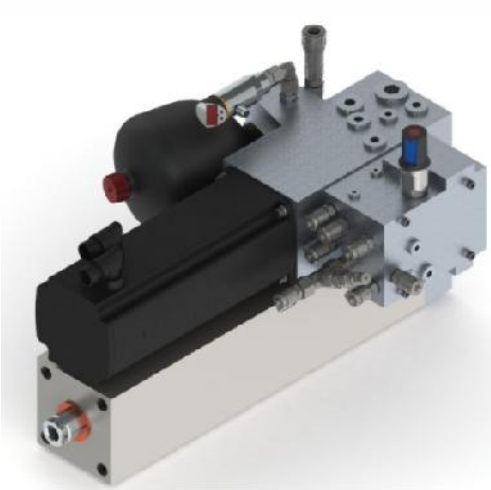




# 2. CLSP – Adaptive Light Weight EHA

## Application Solution

$F_{MAX}$	85 kN
$V_{FMAX}$	0,09 m/s
$V_{MAX}$	0,37 m/s
mass	60 kg



<http://www.kuka.com>

## Target Application

- a) high moving mass.
  - b) discontinuous speed during adaption.
  - c) continuous process force.
- + heavy press, forming
  - + cutting (high weight tool)
  - + punching (low speed)

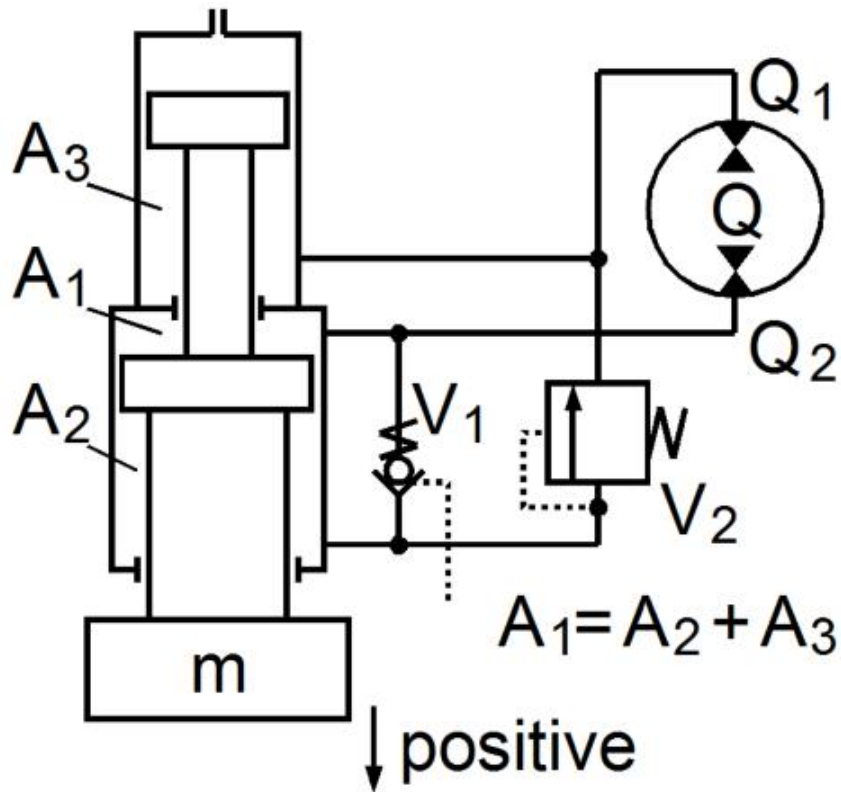
Parameter	Value
$F_{MAX}$	4 MN (400 to)
$V_{FMAX}$	0,03 m/s
$F_{VMAX}$	400 kN (40 to)
$V_{MAX}$	0,27 m/s



<http://www.power-press-machine.com>

### 3. PDSC – Adaptive Heavy Press EHA

#### Function Principle



Mode	V <sub>1</sub>	V <sub>2</sub>	Q <sub>1</sub>	Q <sub>2</sub>
No load positive			A <sub>3</sub>	A <sub>1</sub> - A <sub>2</sub>
No load negative			A <sub>3</sub>	A <sub>1</sub> - A <sub>2</sub>
Full load positive			A <sub>2</sub> + A <sub>3</sub>	A <sub>1</sub>

### 3. PDSC – Adaptive Heavy Press EHA

## Hardware Implementation



Parameter	Value
$F_{MAX}$	4 MN (400 to)
$V_{FMAX}$	0,03 m/s
$F_{VMAX}$	400 kN (40 to)
$V_{MAX}$	0,27 m/s

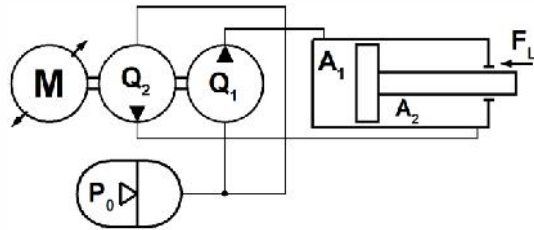
Load power: 120 kW

Feed power: 108 kW

Installed power: 88 kW

### Requirements on Fluids for EHAs

#### Closed loop operation



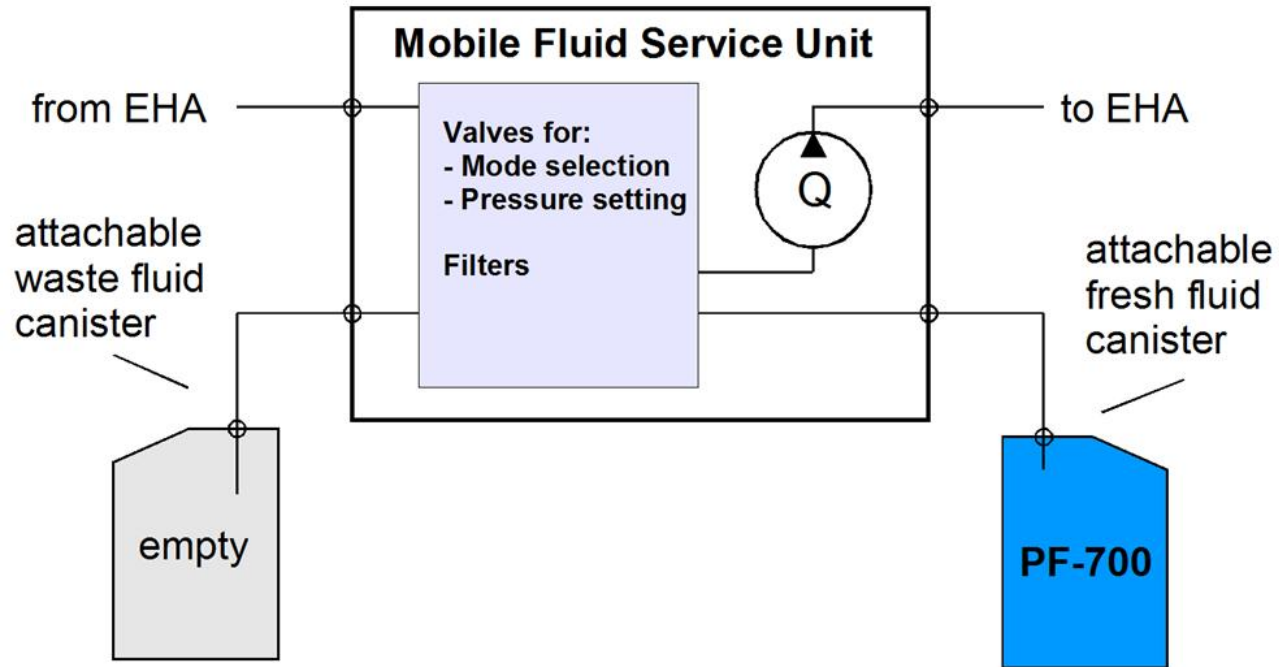
- + No fluid pollution through atmosphere
- Filtering (inline/bypass) will add cost and complexity
- No tank for de-airing
- Fluid must be clean upon startup

#### Pressurized tank

- + Good suction conditions for pumps
- Not easy to replace components / fluid

➔ Fluid care must be supported in system assembly but also in the field!

## Implementation





## Implementation



# 5. Conclusion

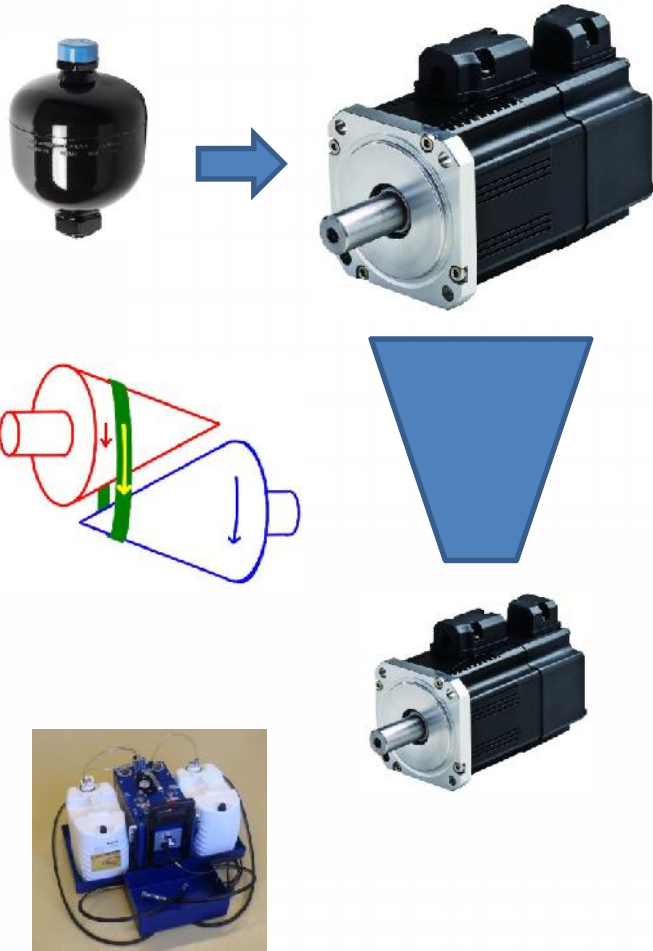
EHAs increase user acceptance and ease of use.

Power-on-demand means giving up averaging input power by use of accumulators.

In contrast to electro mechanical drives, hydraulics allows to create adaptive pitch solution.

Downsizing motor and inverter offers benefits in size, weight and hardware cost.

Closed systems with pressurized tank require special tools for commissioning and service.





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# Thank you for your attention!

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