On Adaptive Electrohydrostatic Actuators

Brahmer, Bert
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1. EHA - Introduction

Time Machine

Looking back to ifk 2012
1. EHA - Introduction

Operating principle of EHA

Differential cylinder and “differential” pump

\[ h_{EHA} = \frac{Q_1}{A_1} = \frac{Q_2}{A_2} \]

Spindle drive

\[ V_{LIN} = \frac{\omega_{MOT}}{2 \times \pi} \times h_{MEC} \]

\[ F_{LIN} = \frac{M_{MOT}}{h_{MEC}} \times 2 \times \pi \]
1. EHA - Introduction

Benefits of EHAs

<table>
<thead>
<tr>
<th>Category</th>
<th>Benefit</th>
</tr>
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<tbody>
<tr>
<td>Compactness</td>
<td>no visible powerpack, pipes, hoses</td>
</tr>
<tr>
<td>Power on demand</td>
<td>no idle consumption in powerpack</td>
</tr>
<tr>
<td>Power efficiency</td>
<td>no throttling losses in servo valves</td>
</tr>
<tr>
<td>Ruggedness</td>
<td>easy to protect against overload</td>
</tr>
<tr>
<td>Safety</td>
<td>implemented easily with logic valves</td>
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</tbody>
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1. EHA - Introduction

Dimensioning

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

Production equipment:

a) feed operation \(\rightarrow\) high speed, low force
b) material processing \(\rightarrow\) 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 → high inertia
High torque → high current, big inverter

Approach:
Move operating point \( F_{\text{MAX}} \) into \( F_{\text{VMAX}} \)
Use smaller motor, inverter.

Implementation:
Use adaptive pitch: \( h = \frac{Q}{A} \)
2. CLSP – Adaptive Light Weight EHA

**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

\[ F_{\text{MAX}} = 85 \text{ kN} \]
\[ V_{F\text{MAX}} = 0,09 \text{ m/s} \]
\[ V_{\text{MAX}} = 0,37 \text{ m/s} \]
\[ \text{mass} = 60 \text{ kg} \]

http://www.kuka.com
3. PDSC – Adaptive Heavy Press EHA

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)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>$F_{\text{MAX}}$</td>
<td>4 MN (400 to)</td>
</tr>
<tr>
<td>$V_{\text{FMAX}}$</td>
<td>0,03 m/s</td>
</tr>
<tr>
<td>$F_{\text{VMAX}}$</td>
<td>400 kN (40 to)</td>
</tr>
<tr>
<td>$V_{\text{MAX}}$</td>
<td>0,27 m/s</td>
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</table>

http://www.power-press-machine.com
3. PDSC – Adaptive Heavy Press EHA

Function Principle

A_1 = A_2 + A_3

<table>
<thead>
<tr>
<th>Mode</th>
<th>V_1</th>
<th>V_2</th>
<th>Q_1</th>
<th>Q_2</th>
</tr>
</thead>
<tbody>
<tr>
<td>No load positive</td>
<td></td>
<td></td>
<td>A_3</td>
<td>A_1 - A_2</td>
</tr>
<tr>
<td>No load negative</td>
<td></td>
<td></td>
<td>A_3</td>
<td>A_1 - A_2</td>
</tr>
<tr>
<td>Full load positive</td>
<td></td>
<td></td>
<td>A_2 + A_3</td>
<td>A_1</td>
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3. PDSC – Adaptive Heavy Press EHA

Hardware Implementation

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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-aering
- 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!
4. Mobile Service Unit

Implementation

Mobile Fluid Service Unit

- Valves for:
  - Mode selection
  - Pressure setting
- Filters

from EHA

attachable waste fluid canister

empty

PF-700

attachable fresh fluid canister
to EHA
4. Mobile Service Unit

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.
Thank you for your attention!

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