Multidirectional presses as preforming units for aluminium and titanium alloys

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Multidirectional hydraulic hot forging

Contents of the presentation:

1. Processes and applications
2. Lateral extrusion
3. Die forging
   3.1. Hydraulic horizontal forging machines
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Applications of multidirectional presses

A. Lateral extrusion

- Tripodes
- Tube fittings
- Bevel gears
- Ball hubs
Applications of multidirectional presses

B. Die forging

Large crankshafts

Turbine blades
Process sequence of lateral extrusion

• Up to 4 press axes (upper/lower punch, upper/lower die)

• Flashless forging

• Forging units: multidirectional hydraulic presses, closing devices in single-acting presses
Hydraulic lateral extrusion press – schematic sketch

- Separation of tool closing movement and forming process

Quelle: IFUM
Process steps of a turbine blade

Pre-form 1

Pre-form 2
Mechanical horizontal forging machines - function

- Rigid mechanical connection between clamping drive and main/upsetting drive
- Mutual interference of the drives
- Stroke-bound machine
- High output, energy-efficient
Hydraulic horizontal forging machine HWS

- Independent hydraulic drives for upsetting and clamping
- Clamping force 50% higher than upsetting force
- Time overlap of clamping and upsetting drive can be freely selected
- Easily adjustable to different tool heights and upsetting distances
- Energy-saving modern hydraulic drive technology
Hydraulic horizontal forging machine HWS – hydraulic concept

**Upsetting drive**
- Elongation: 0.5 mm
- Forming: 1.5 mm
- Forming speed: 0.5 mm/s
- Clamping force: 3000 KN
- Hub: 500 mm

**Clamping drive**
- Elongation: 0.5 mm
- Forming: 1.5 mm
- Forming speed: 0.5 mm/s
- Clamping force: 20000 KN
- Hub: 500 mm
- Forming speed: 0.5 mm/s
Hydraulic servo direct drive

Conventional drive

Hydraulic servo direct drive
**Comparison standard / servo direct drive – energy consumption**

30 min. of production with the same tools/parts

<table>
<thead>
<tr>
<th></th>
<th>Press 1 (standard)</th>
<th>Press 2 (servo direct drive)</th>
<th>SOP: October 2012</th>
<th>Counter: 24,5 mio strokes on 15.02.2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of measurements</td>
<td>23.10.12</td>
<td>28.10.12</td>
<td></td>
<td></td>
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<tr>
<td>Duration [min]</td>
<td>30</td>
<td>30</td>
<td></td>
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<tr>
<td>No. of strokes/min.  [1/min]</td>
<td>28.5</td>
<td>40</td>
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<td></td>
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<tr>
<td>Parts produced [-]</td>
<td>850</td>
<td>1200</td>
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<tr>
<td>Peak power [kW]</td>
<td>265</td>
<td>225</td>
<td></td>
<td></td>
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<tr>
<td>$\cos \varphi$ (average)</td>
<td>0.65</td>
<td>0.93</td>
<td></td>
<td></td>
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<tr>
<td>Total energy consumption [kWh]</td>
<td>95</td>
<td>84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy consumption/part [Wh/part]</td>
<td>111</td>
<td>70</td>
<td></td>
<td></td>
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<tr>
<td>Mean oil temperature [° C]</td>
<td>57</td>
<td>41</td>
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</tbody>
</table>

36.9% less energy/part
Comparison of energy consumption

Observations:

- Mean oil temperature approx. 41° C
- 50% less cooling water consumption
- Motor temperature 56 / 75° C
- Oil samples show no signs of wear (after approx. 25 million strokes!)
Economic aspects

303 workdays, 2-shift-operation à 8h, 90% availability

⇒ 10.47 million parts per year

<table>
<thead>
<tr>
<th>Standard</th>
<th>Servo direct</th>
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<tbody>
<tr>
<td>111 Wh/part</td>
<td>70 Wh/part</td>
</tr>
<tr>
<td>1.162.170 kWh/a</td>
<td>732.900 kWh/a</td>
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</tbody>
</table>

429.270 kWh/a  (≈ approx. 112 budgets/a)

Energy costs approx. 15 Ct/kWh ⇒ approx. 65.000 €/a

Excluding: reactive power compensation, cooling water preparation, etc.
Hydraulic servo direct drive

• Servo motor + constant pump directly connected (no valves)

• Direct regulation of position and pressure (force)

• Pressure dwell time

• Pressure reduction with energy recovery
Hydraulic servo direct drive

Function

- Tank
- Fill valve with control
- Cylinder
- Pressure transformer - pressing -
- Stroke measuring system
- Synchronous motor \( n = \text{variable} \)
- Servo pump \( V = \text{const.} \)
- Control unit
- Pressure transformer - lifting -
- Servo pump \( V = \text{const.} \)
- Synchronous motor \( n = \text{variable} \)
- Converter with buffer and energy storage
Flexible hydraulic preforming unit - FlexiMat

Modular construction

Up to three die impressions in series

Up to four press axes
FlexiMat – producible shapes

<table>
<thead>
<tr>
<th>Vorformgeometrien</th>
<th>Kombinationsformen</th>
<th>Kombinationsformen</th>
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<tbody>
<tr>
<td>VF1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>VF2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>VF3</td>
<td>0</td>
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<tr>
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</tr>
<tr>
<td>VF6</td>
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<td>1</td>
</tr>
<tr>
<td>VF7</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Diagram showing different shapes and their combinations.
FlexiMat 40/60 – hydraulic preforming unit

Vertical axis
6,000 kN

Horizontal axis
4,000 kN each
Forging processes for crankshafts

- Die forging
  (presses, hammers)

- TR-process
  (hydr. presses)

- Single stroke process
  (multidirectional hydr. presses)

- Open die forging
  (open die presses)

Crankshaft length

2.5 m  5 m  7.5 m  10 m  12.5 m  15 m
Crankshaft forging in single stroke process - principle

- n-th crank pin
- partial heating
- partial forging
- 1. crank pin
- flange

Source: Mercedes
TR forging process for large crankshafts

Single-acting hydraulic press

Mechanical coupling of upsetting and offsetting forces
Press axes of a multidirectional press for large crankshafts
Multidirectional press for large crankshafts CSPC 31000

Counterforce cylinder

Clamping ram

Upsetting ram

Upsetting ram

Crosshead upsetting

Offsetting cylinder

Crosshead clamping