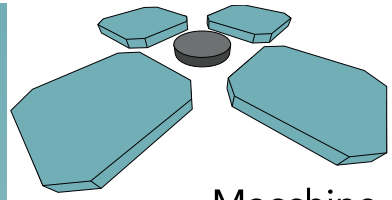

MUSP

Macchine Utensili e Sistemi di Produzione

ECO-DESIGN OF FORMING MACHINES

Matteo Strano *matteo.strano@polimi.it*
Paolo Albertelli

Outline of the presentation

- Examples of energy measurements on metal forming machines
  - 6 case studies
    1. press-brakes for sheet bending (literature)
    2. Measurements for deep drawing/stamping presses: electrical servo-press
    3. Measurements for deep drawing/stamping presses: hydraulic press
    4. Electric vs. hydraulic tube bending machine
    5. planetary cutting of tubes by deformation machine
    6. hydraulic press for powder forming
  - Lessons learned
- Example on a wood cutting machine
- Actions for Ecodesign of forming presses
  1. Improve or change the **drives**
  2. Improve the **control**
  3. Improve the **process**
  4. Improve the **structure** (environmental optimization)

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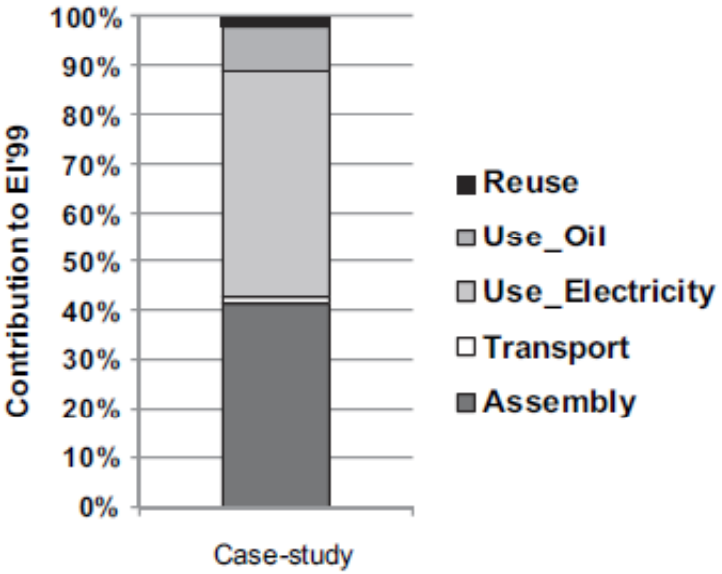
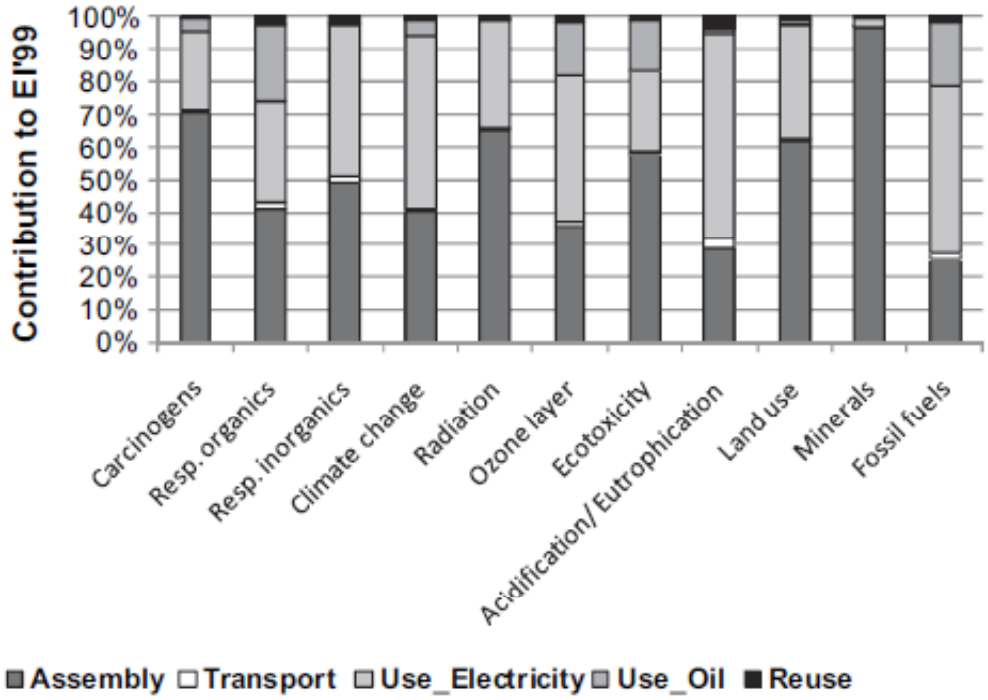
Examples of measurements (1)

- Hydraulic press-brake for sheet bending (literature)
  - Pressing force: 110 tons
  - Bend length: 3000 mm
  - Main motor power: 7.5 kW
  - Weight: 7 tons

Environmental IMPACT
ECO-INDICATOR 99

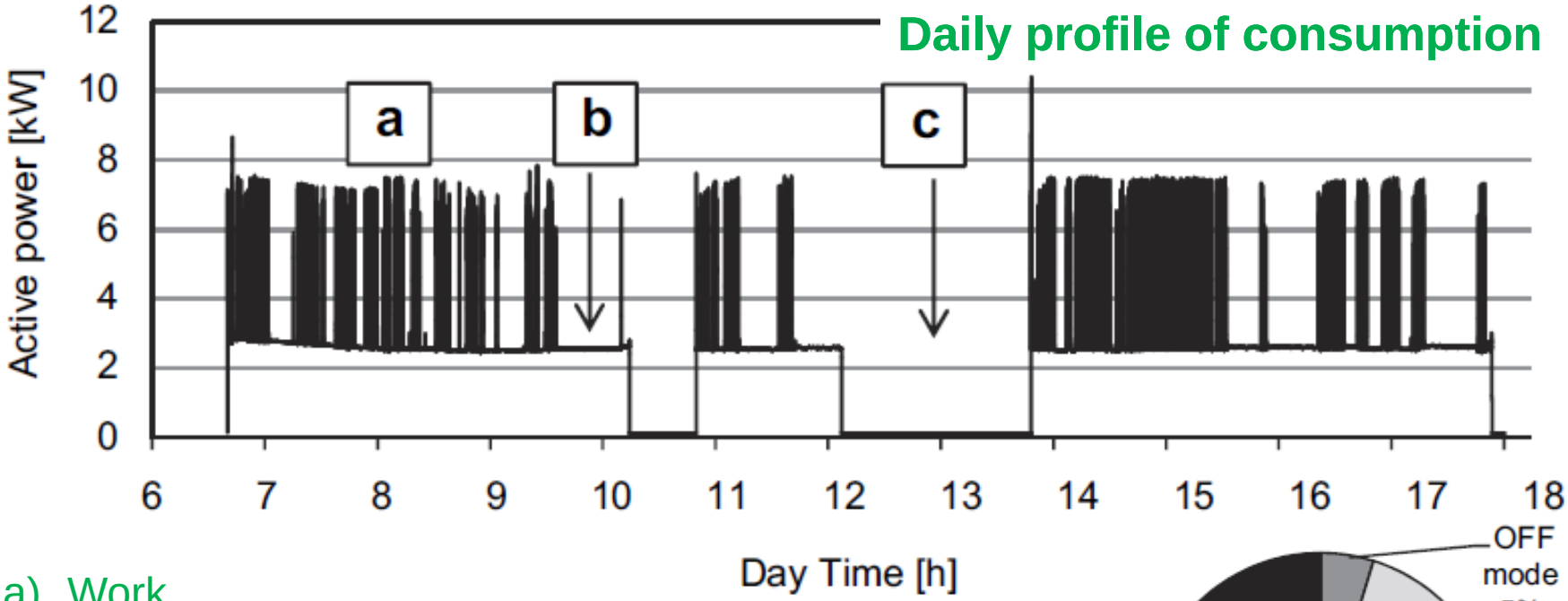




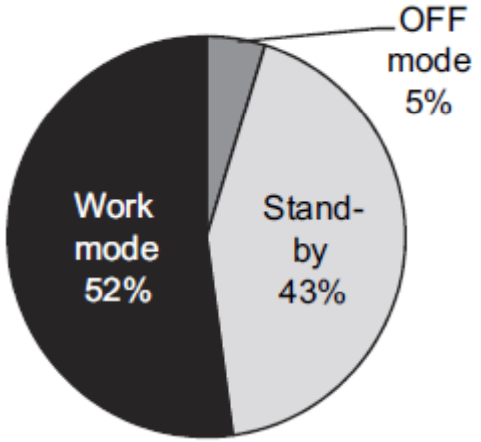
Examples of measurements (1)

- Hydraulic press-brake for sheet bending (literature)
  - Pressing force: 170 tons, Main motor power: 15 kW

Daily profile of consumption



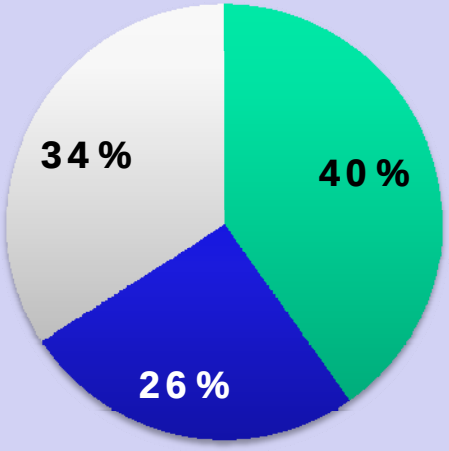
a) Work
b) Stand-by
c) Off



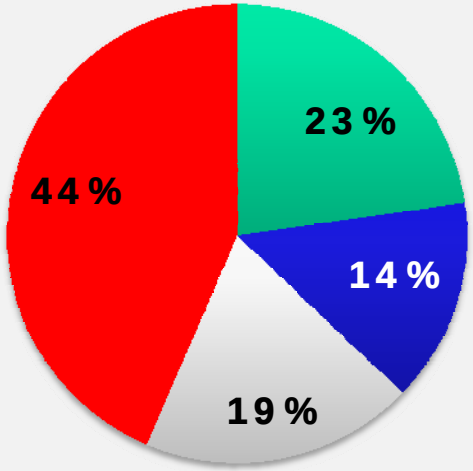
Examples of measurements (2)

- Electric servo-press for stamping (320 tons)

Power Consumption ~8 kW
No Load Operation Mode



Power Consumption ~12 kW
Standard Working Mode



- 67 strokes/min
- **85 tons** max pressing force

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Lessons learned

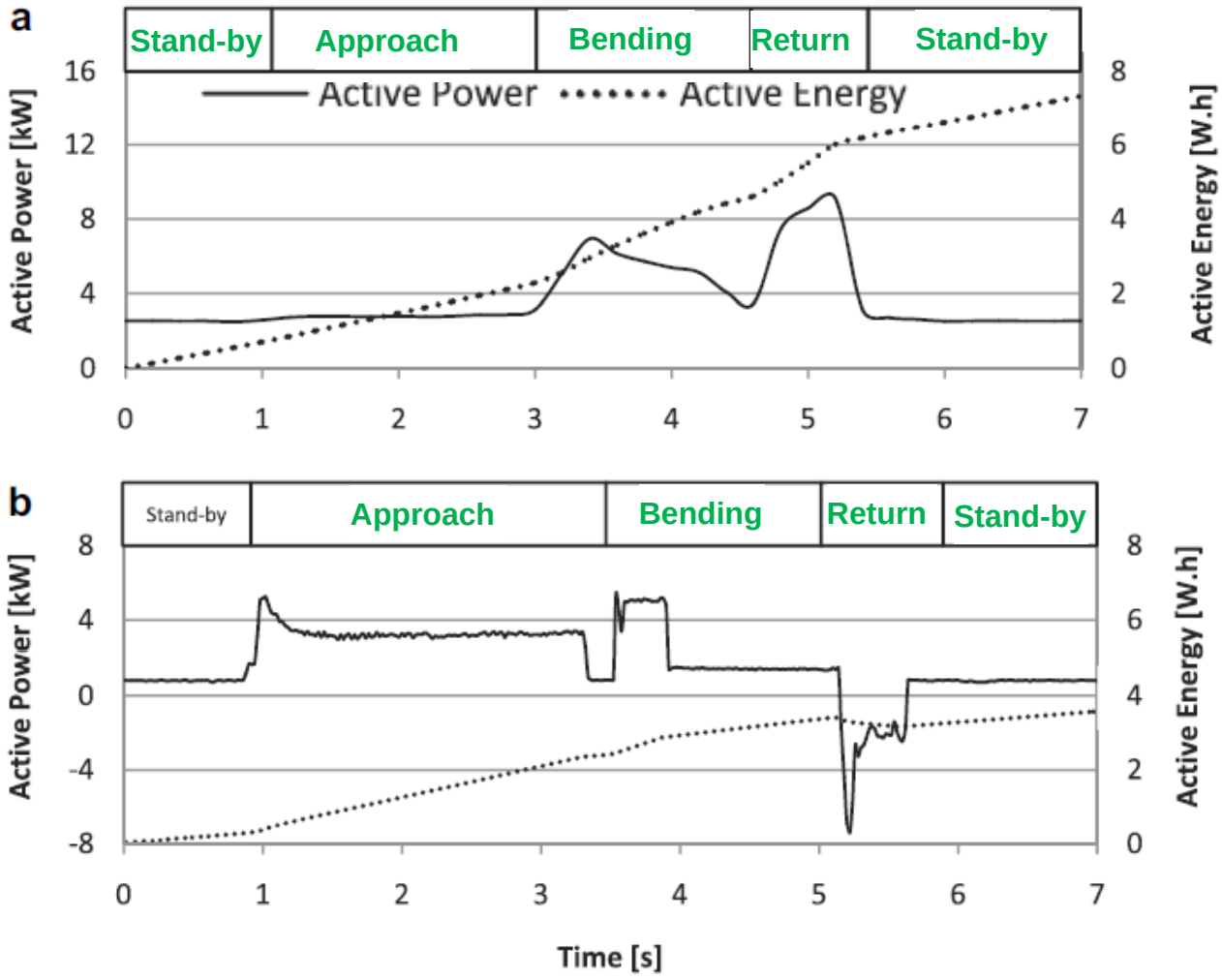
- In forming operations, a great % of total energy goes into:
  - Turning on the machine, without moving it!
    - for both hydraulic and electric machines
      - idle times *due to scheduling and dispatching rules, setup times* are vey important
      - Minimizing the duration of a single cycle is crucial
      - Finding new ways of reducing the stand-by energy consumption is required

Examples of measurements (1)

- Hydraulic vs. electric bending press-brake (literature)
  - *1:2 ratio in average power*

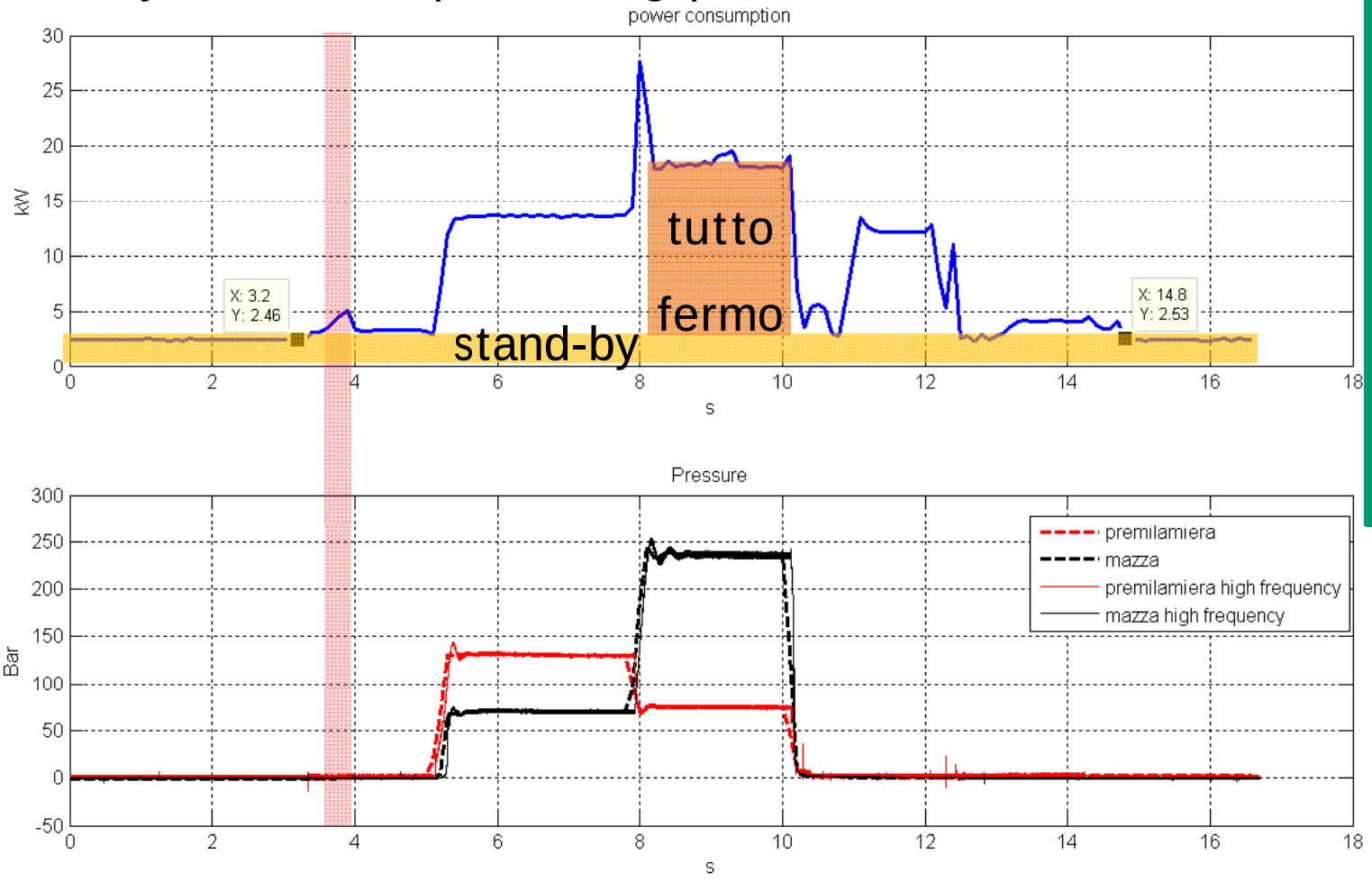
Hydraulic, 110 tons
Main motor power 11 kW

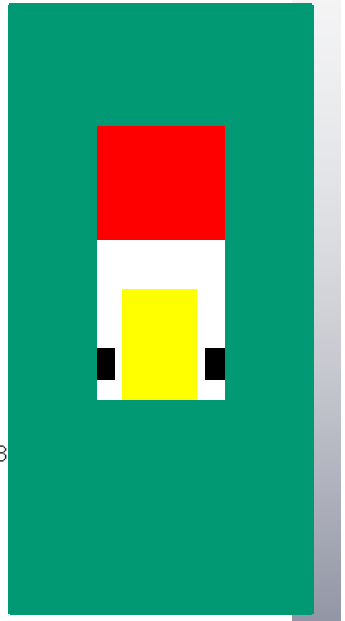
Electric, 100 tons
Main motor power 11 kW



Examples of measurements (3)

- Hydraulic deep drawing press





stand-by: 25-30% del consumo energetico totale

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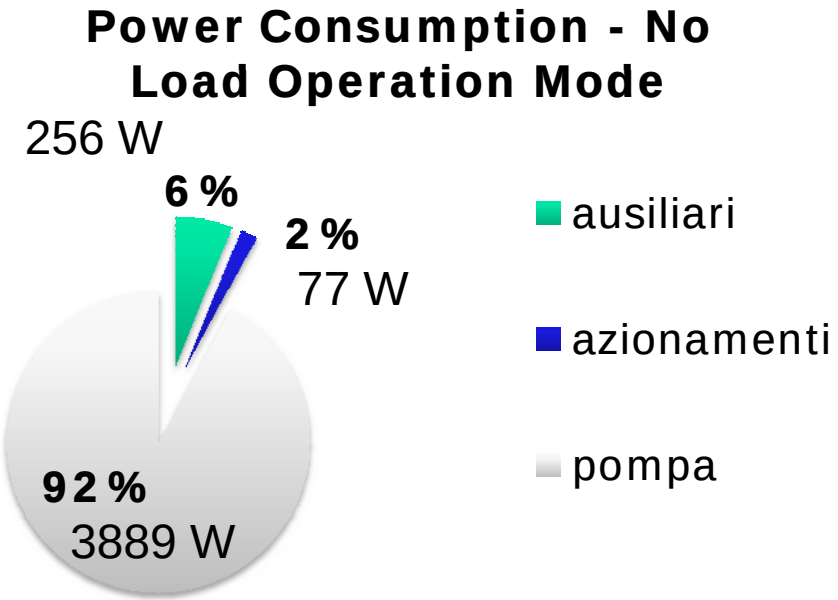
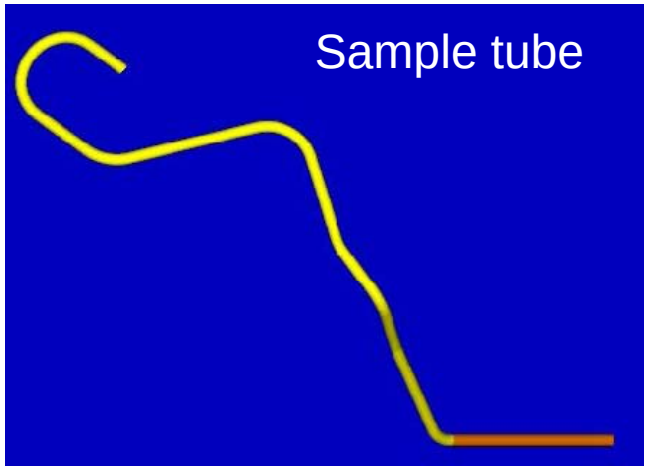
Examples of measurements (4)

- Hydraulic tube bending machine



Tube bender 880VGP



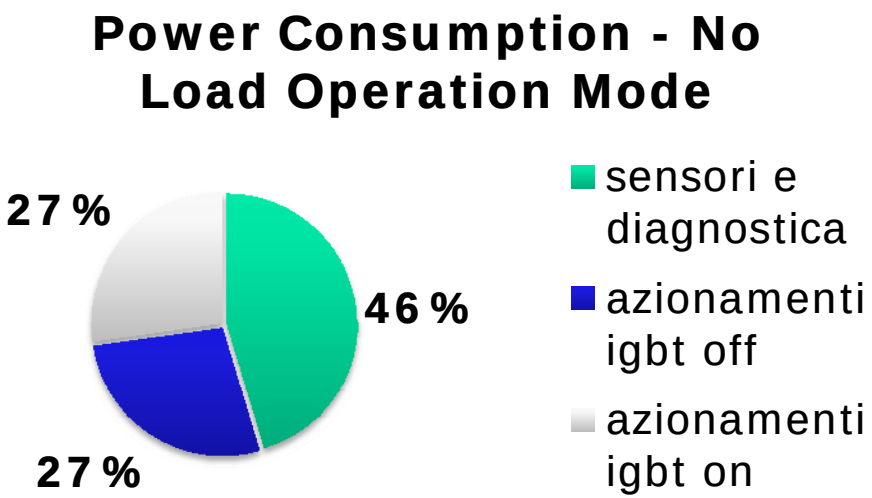
Simulated process (no tube)

Ready to work → **20.1 kW**

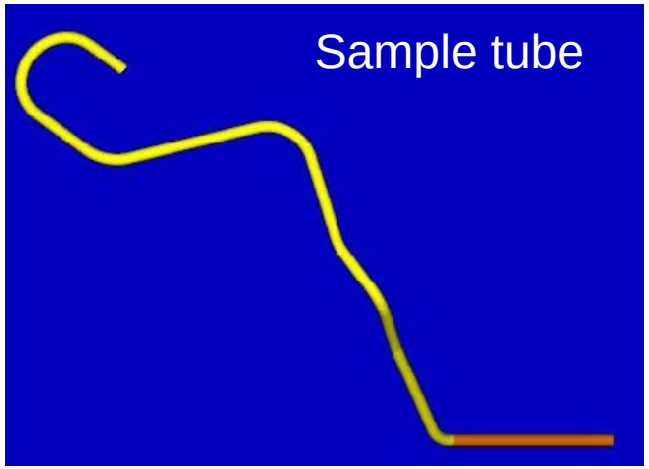
4.2 kW

Examples of measurements (4)

- Hydraulic tube bending machine
  - Comparison with all electric
    - *1:10 ratio in average power*



Tube bender elect80



Simulated process (no tube)

Ready to work → **2.2 kW**

0.8 kW

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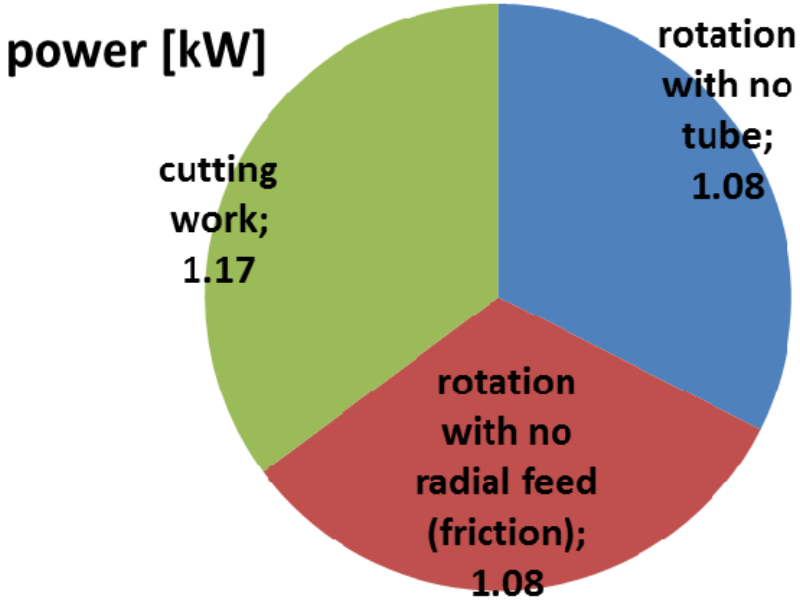
Lessons learned

- In forming operations, a great % of total energy goes into:
  - Turning on the machine, without moving it!
    - for both hydraulic and electric machines
      - idle times *due to scheduling and dispatching rules, setup times* are vey important
      - Minimizing the duration of a single cycle is crucial
      - Finding new ways of reducing the stand-by energy consumption is required
  - Hydraulic drive in itself (vs. electric drives)
    - Particularly inefficient are energies spent while the tools are not moving, within one pressing cycle
    - Especially, but not exclusively for medium tonnage operations ~10÷100 tons (e.g., tube bending, press brakes)

Examples of measurements (5)

- Hydraulic/electric planetary cutting of tubes by deformation
  - Energetic load due to radial feed is negligible
  - Rotational power is largely due to the moving masses of the machine itself and to the mechanical losses in the transmissions



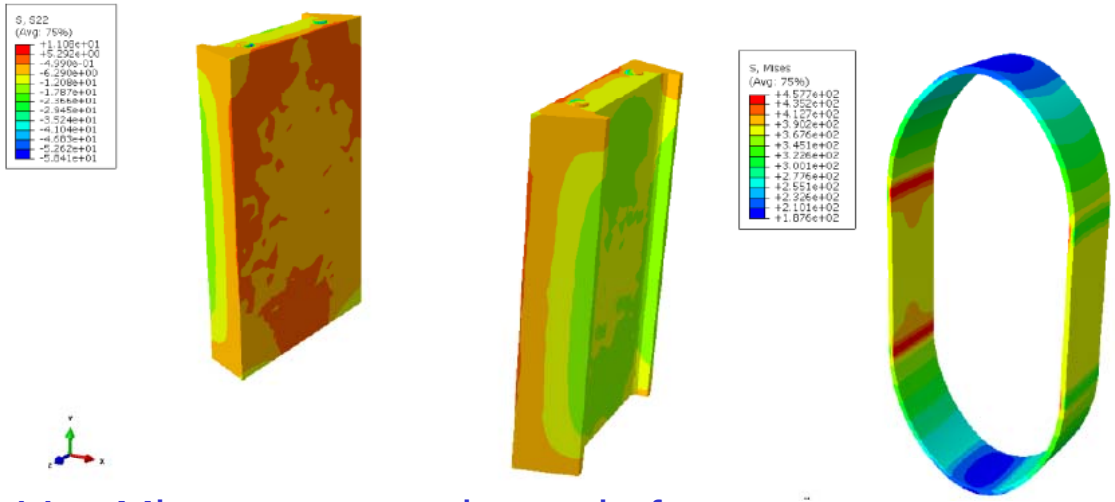
Electric drive for rotation (3kW)

Outer diameter: 800 mm

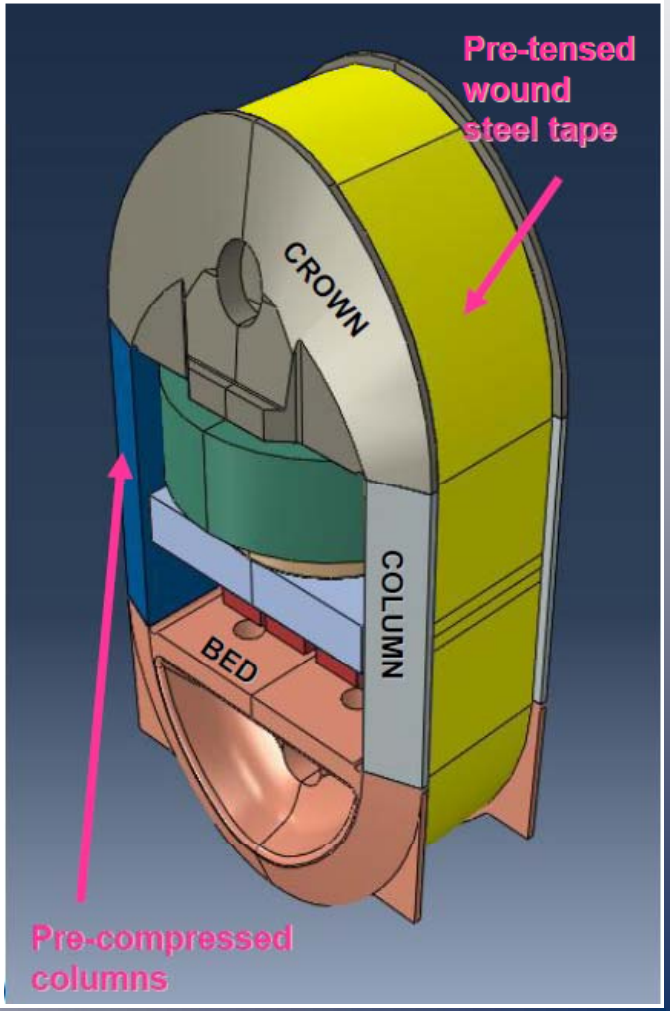
HDPE tube

Examples of measurements (6)

- Hydraulic pre-stressed press for powder forming
  - ENERGY spent for deflection of the structure
    - **45 kJ per stroke**
  - ENERGY spent for forming
    - **49 kJ per mm of stroke**



Von Mises stress at the end of pressing on columns and wire



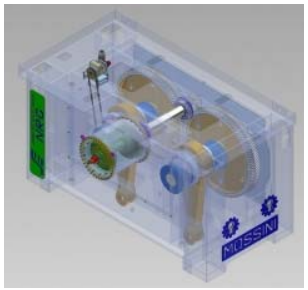
Single effect hydraulic drive 5000 tons

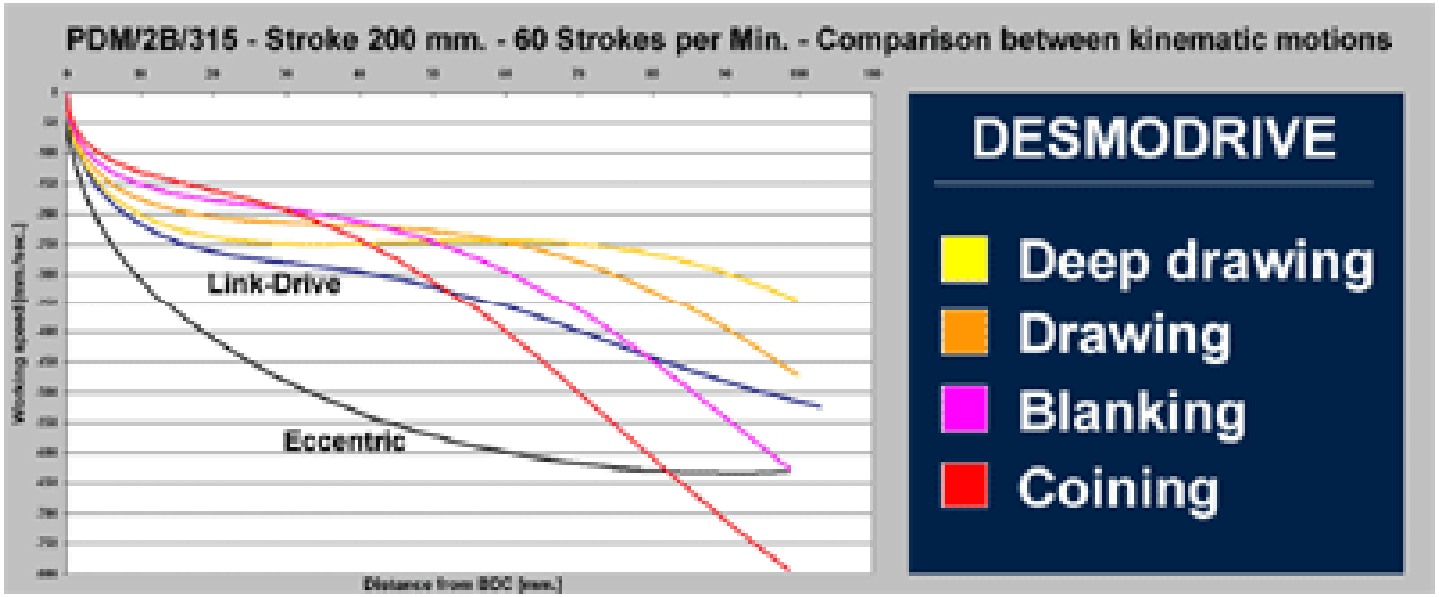
Lessons learned

- In forming operations, a great % of total energy goes into:
  - Turning on the machine, without moving it!
  - Hydraulic drive in itself (vs. electric drives)
  - Making the machine move, without actually working the material
    - Inertial and gravitational losses of the machine
  - Frictional losses
  - Elastic deformation of machine and tools
    - Especially, but not exclusively for large tonnage operations >1000 tons (e.g. large forgings, powder forming, hydroforming)

1. Improve or change the drives / control / process

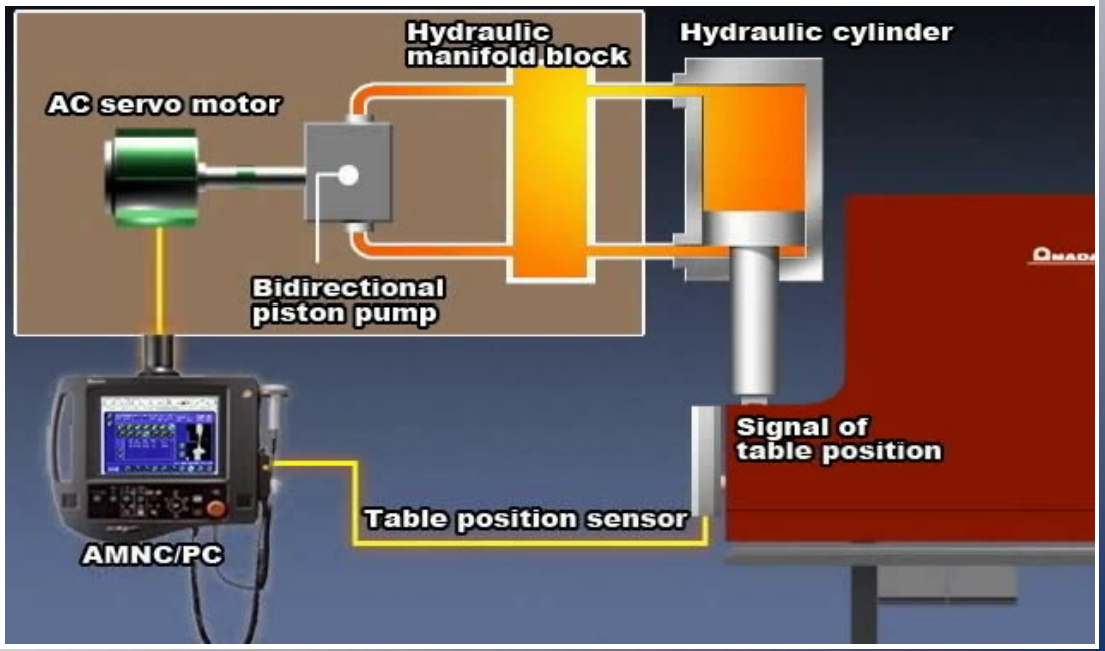
- Alternative strategies
  - Move from hydraulic to all-electric
  - Move from conventional mechanical presses to servo-presses
    - Servo-presses equipped with torque motors
    - To be compared with a conventional mechanical press
    - Desmodrive for conventional presses (to optimize the stroke)





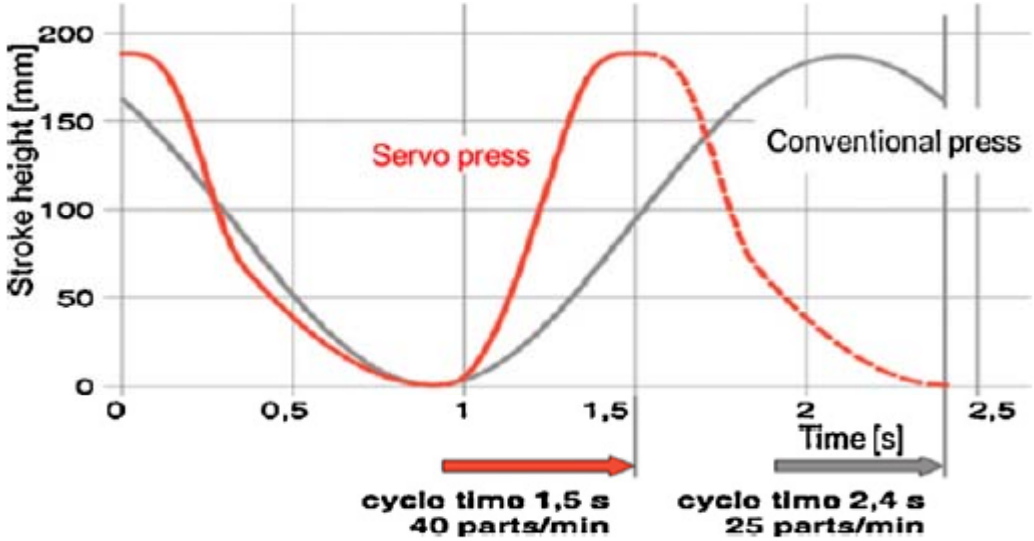
1. Improve or change the drives / control / process

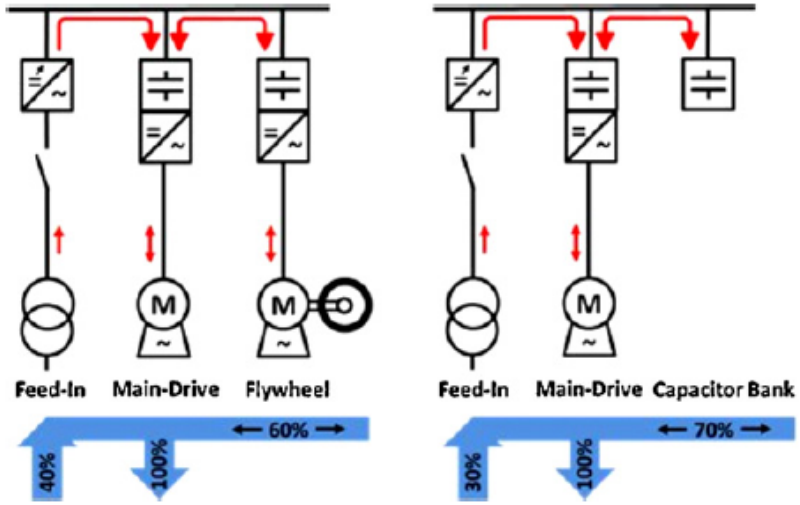
- Alternative strategies
  - Explore hybrid solutions
    - Some axes can be electric
    - Some can be hydraulic
  - Improve hydraulic drives, e.g. the
    - Siemens servo-pump
    - AMADA servo-hydraulic press brakes
    - Rexroth 4EE approach



2. Improve the control / drives/ process

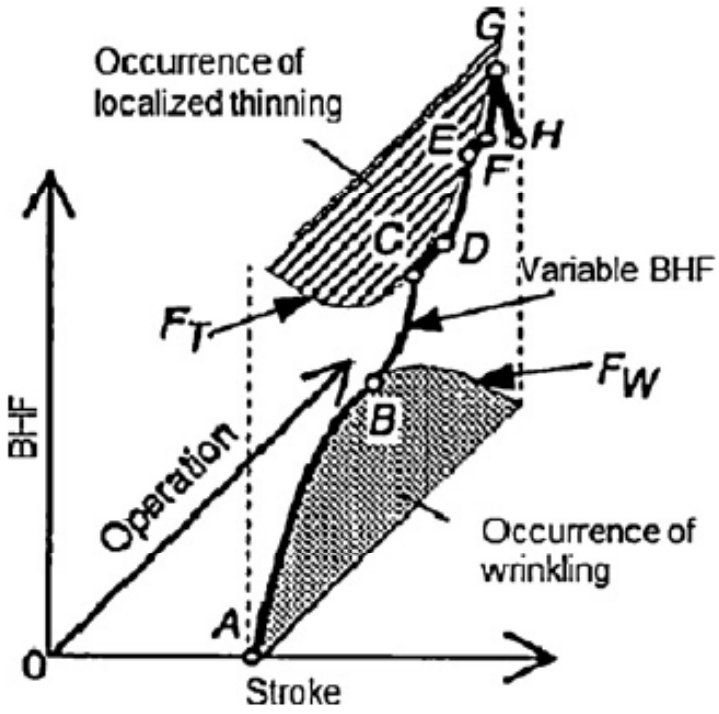
- Make machines smarter: servo presses can be used to:
  - Optimize the stroke
  - Optimize the process (e.g. blankholder force control in deep drawing)
  - Recover energy both from main slide and cushion





3. Improve the process / drives/ control

- Optimize the process parameters (through FEM)
  - Smarter machines require more skilled and better equipped process planners

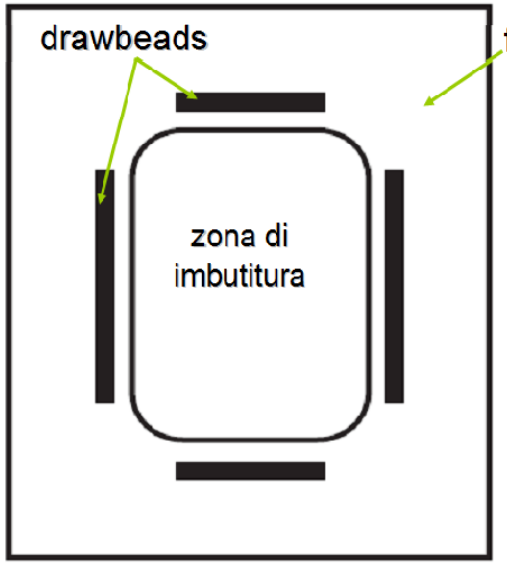


- Reduce process friction through enhanced tribology
  - Better lubricants
  - Better coatings

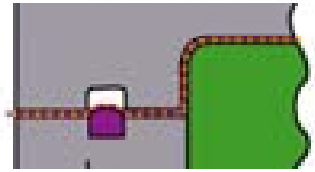
3. Improve the process / drives/ control

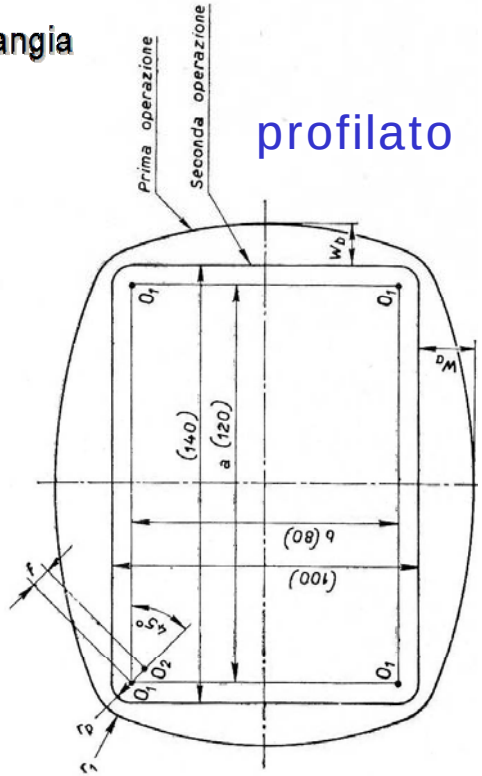
- Optimize the process parameters (through FEM)
  - As an example, in deep drawing when the risk of wrinkling is large, the radial draw-in can be controlled in different ways:

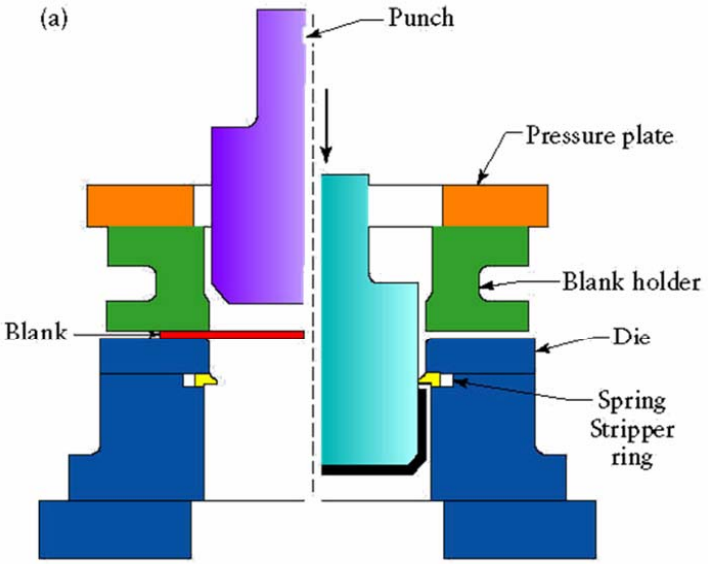
Drawbead control **or** Blank shape control **vs.** Blankolder force control



Conventional Drawbeads







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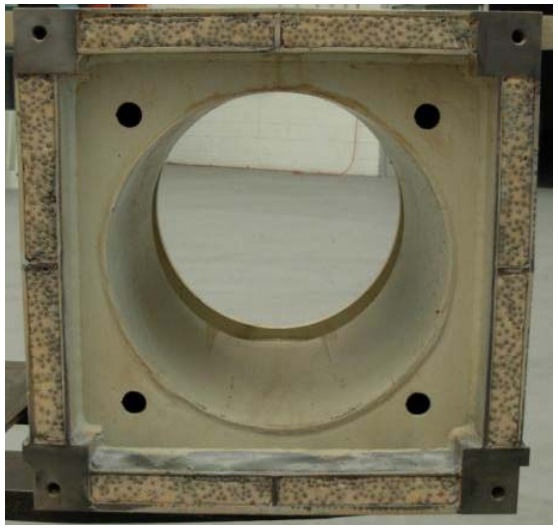
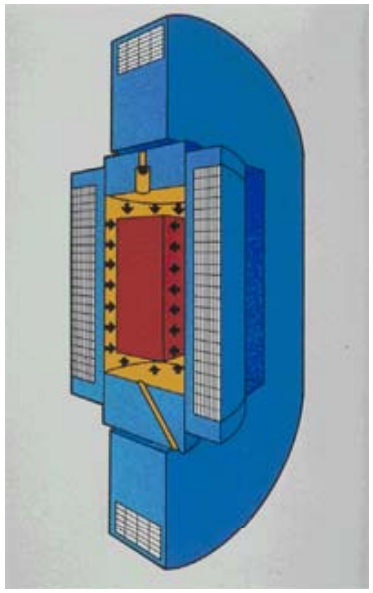
4. Improve the structure

- Environmental optimization of press frames
  - Stiffer structures deflect less, but do require more material (are heavier)
    - There is a trade-off between lightness and stiffness



Light weight construction materials



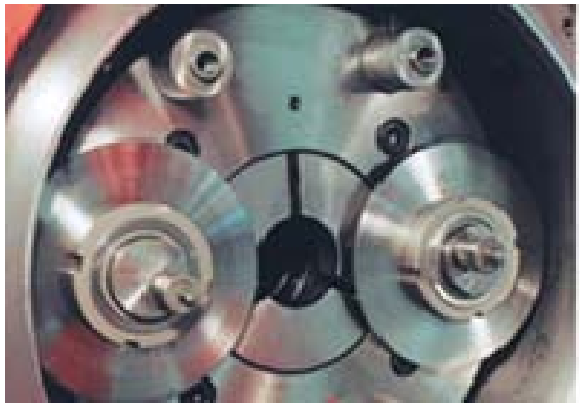
Pre-stressing of monolithic structures as an option for optimization

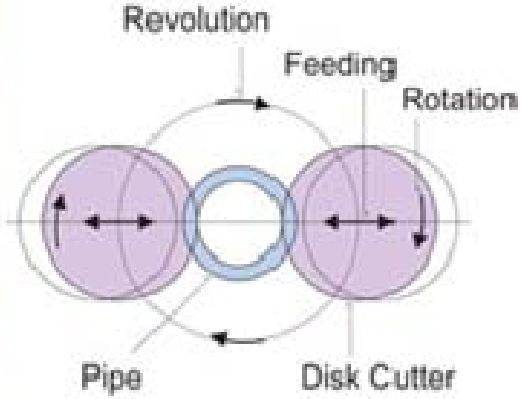
4. Improve the structure

- Reduce gravitational and inertial effects
  - Use horizontal axes, when possible

horizontal hydraulic forging press

  - Avoid heavy rotational axes, when possible





rotary metal pipe cutter by deformation

CONCLUSIONS

- In forming operations, a great % of total energy goes into:
  - Turning on the machine, without moving it!
  - Hydraulic drive in itself (vs. electric drives)
  - Making the machine move, without actually working the material
  - Frictional losses
  - Elastic deformation of machine and tools

The main actions for ECODESIGN of forming machines

1. Improve or change the drives
2. Improve the control
3. Improve the process

} Strictly related tasks

4. Improve the structure (environmental optimization)

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