

Solid Wood Bending

Process Steps from Tree to Chair



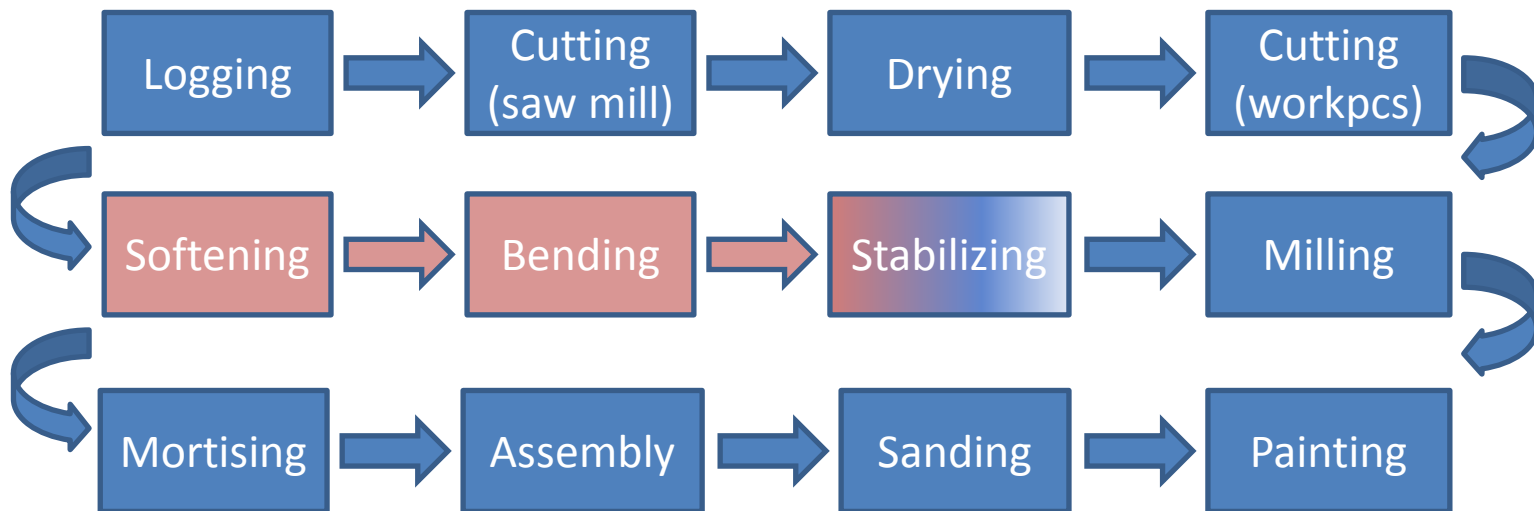
- Solid Wood Bending was developed by the German Michael Thonet around 1840 in Vienna (Austria) for the production of contemporary chairs.
- The so called „Thonet Method“ to bend wood uses a strap along the outside of the bending to avoid tensile stress.
- Within 50 years after the presentation of the Thonet chair „No. 14“ (called „Vienna Coffe House Chair“) in 1850, Thonet produced approx. 50 Mio. units just of this type.
- While the back part of No. 14 still is a manual bending, most other bend parts can be made by using bending machines.
- Bending wood avoids waste and increases the yield of the material.
- Because of the compression during the process, bended parts have better mechanical properties (elasticity, durability, stability) then from any other wood forming technology (formed plywood, cutted solid wood, ...).

Introduction (2)

- A bend shop consists of
 - Softening device (autoclaves & steam generator)
 - Bending Machine
 - Space for bended parts during stabilisation
 - Everything else are standard machines & devices for the chair production



- Typical application for solid wood bending:
 - production of chairs
 - toboggans and sledges
- No special process required apart from bending
(softening, bending, 1st phase of stabilizing)



Preparing Wood (1)

- Harvesting Wood
 - logging
 - forwarding



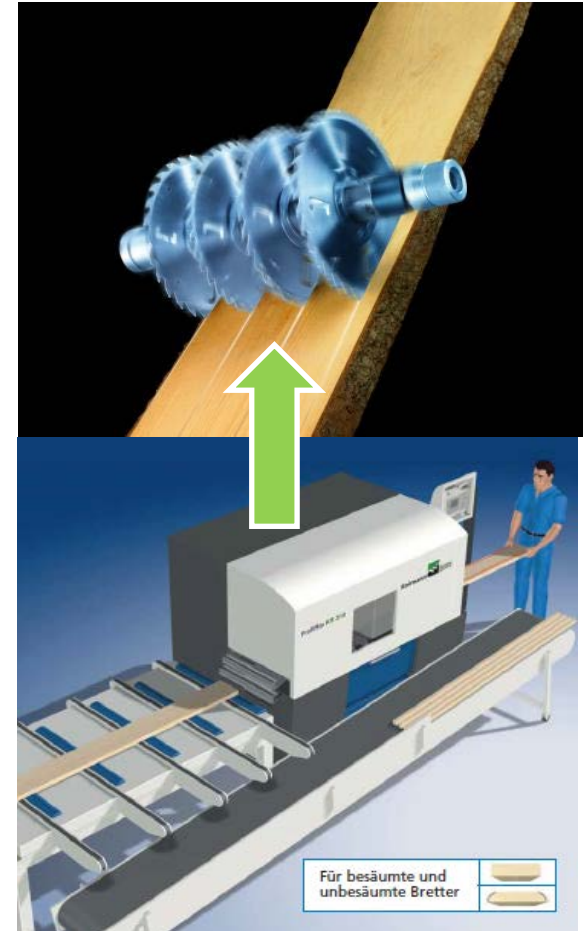
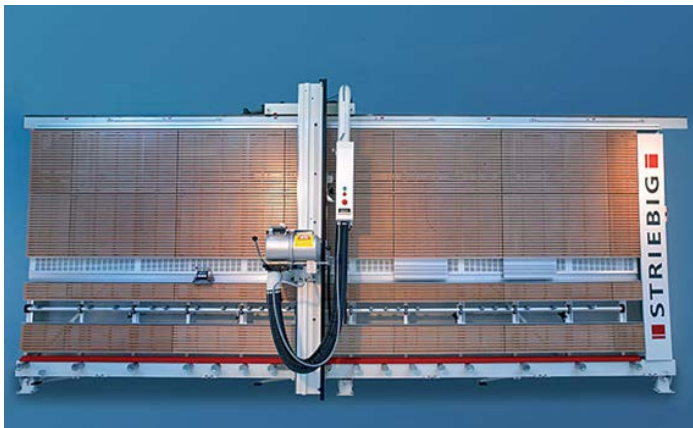
Preparing Wood (2)

- Cutting
(saw mill)
- Drying
(kiln dryer)
 - for furniture production
 $mc \approx 12\%$
 - for wood bending
 $mc \approx 15 \dots 20\%$



Preparing Wood (3)

- cutting (preparing specific workpieces) for
 - table legs
 - table frames
 - chair legs
 - misc. chair parts
(frame, backrest, armrest, ...)



Preparing Wood (4)

- Planning
(if necessary)



Solid Wood Bending (1)

- softening / steaming



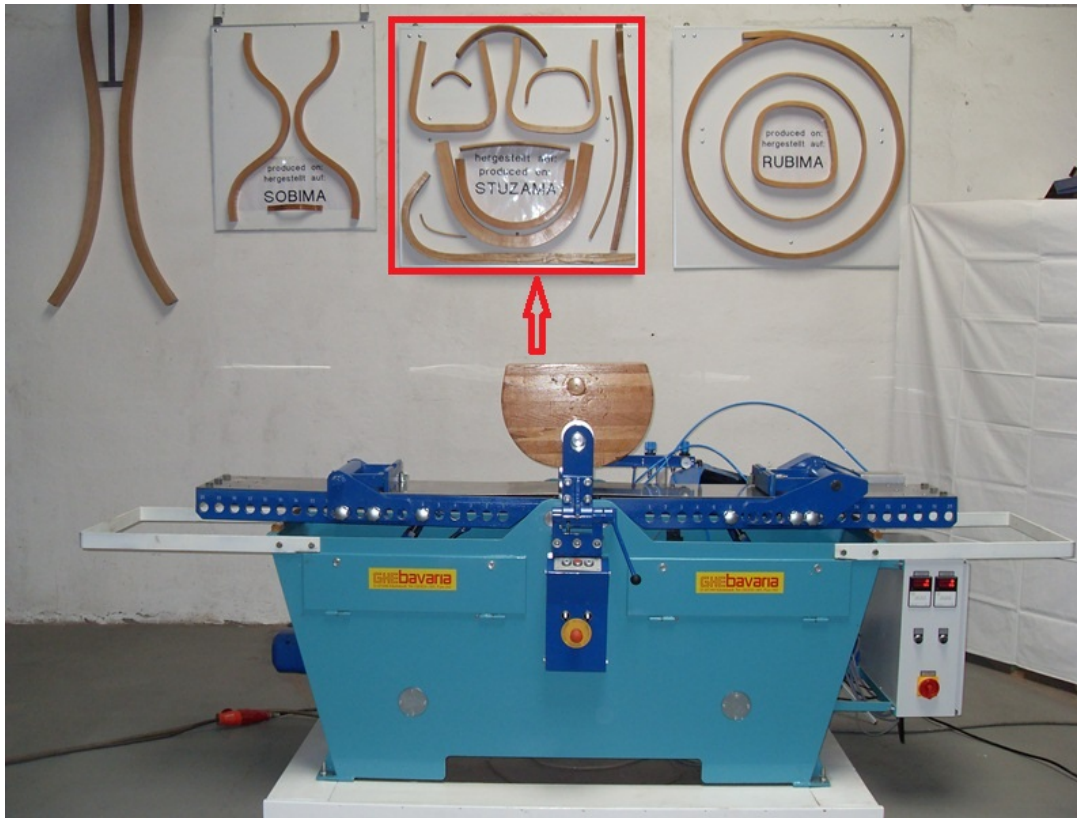
Autoclaves available in different sizes according to required production capacity, e.g.:

- Ø 600 mm
- Ø 800 mm
- L 1 000 ... 2 000 mm
- steam generator 12 ... 54 kW
- Compact unit with steam generator 12 kW & autoclave Ø 600 mm x 1200 mm

Softening approx. 1 ... 2 min per mm wood thickness

Solid Wood Bending (2)

- bending



A wide range of bending machines available depending on shape and thickness of workpiece,

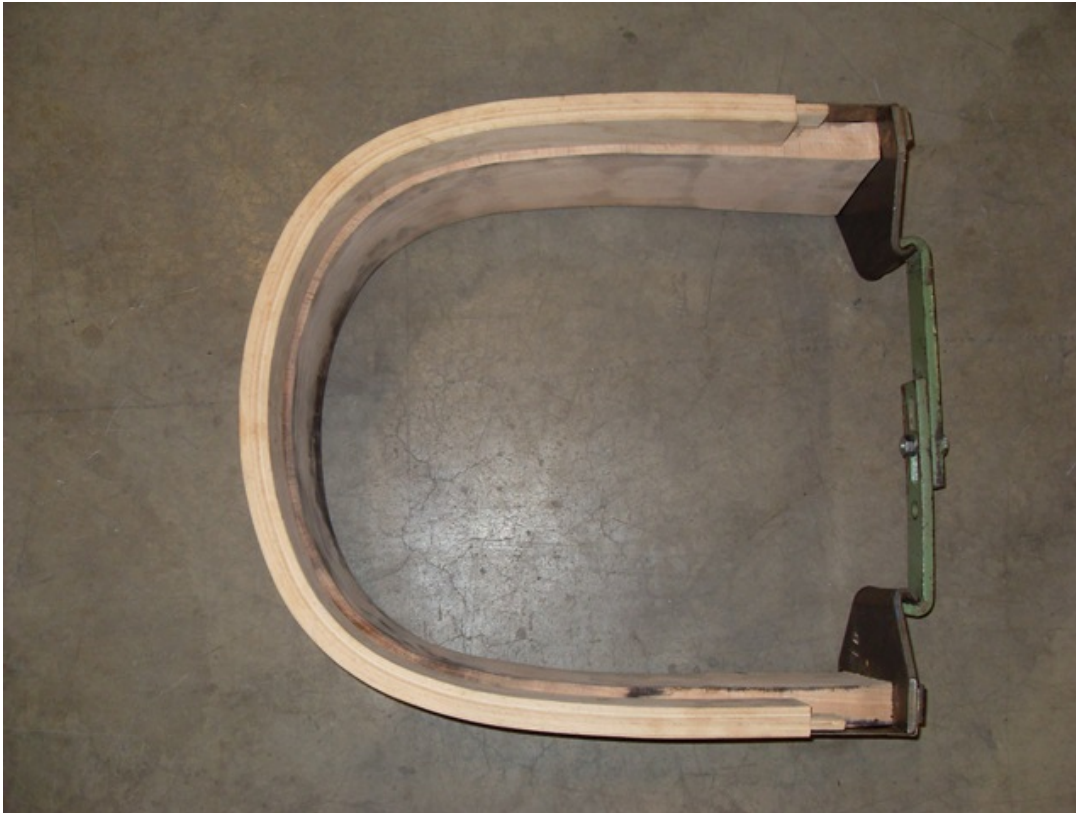
- for U shapes (Stuzama)
L 1200 ... 2000 mm
- for O bendings (Rubima)
L 2000 ... 3500 mm

Manual bending reasonable for low production volume.

Fig.: Stuzama II solid wood bending machine and parts spectrum

Bending cycle time approx. 30 ... 60 s, depending on shape & wood thickness

- stabilizing



For the bending process, a strap and clamp is needed (1 per bending cycle).

The strap & clamp stay with the workpiece until this has cooled down during stabilizing. Then, clamp & strap are removed.

Fig.: Bended parts- raw workpiece (below), finished chair frame (top).

Stabilizing time approx. 30 ... 90 min, depending on thickness & moisture

Post Processing (1)

- drying



Drying wood after bending does not require a specific installation. It can be done by natural ventilation (time depending on climate) or in a kiln or a vacuum dryer (fast). However, it should have max. 12% moisture content before further machining.

Post Processing (2)

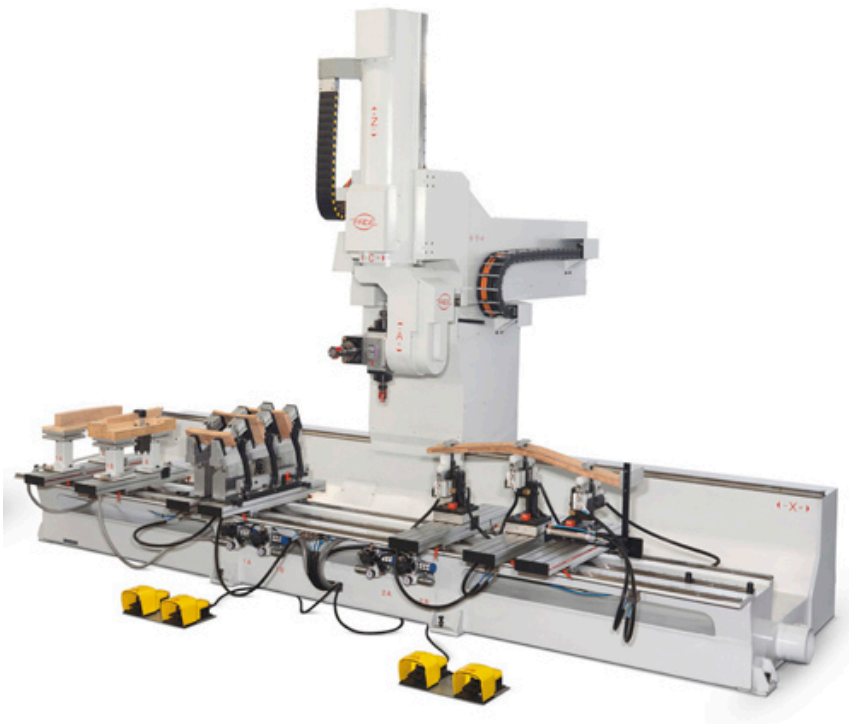
- Milling to shape (manual)



For post-processing of bended parts, the woodworking machine offers a wide range of manual, semi- automatic and CNC machines. Basically all machines for chair production can be used (see following pages).

Post Processing (3)

- Milling to shape (automatic line)



A typical supplier for chair production machines is Pade, Italy.

Post Processing (4)

- Mortising / Slots for joints



Post Processing (5)

- Finishing
 - Vibratory finishing (straight tubs) widely used for chair lines
- Painting



- Different lay-outs are used for chair painting depending on capacity requirements
 - High volume: paint line
 - Low volume: single spray booth

Typical Bentwood Chairs (1)

- Some typical designs:



Thonet Nr. (2)14. The most typical bentwood chair is the most famous and most built chair in the world.



Typical Bentwood Chairs (2)

- Bentwood is extremely tolerant to outdoor exposure



- Bentwood chairs are made from hardwoods (most typical: Beech).
- Teak and Hevea (Rubberwood) can be used, but with some limitations in radius.
- Softwoods (spruce, pine, ...) are not used for bending.

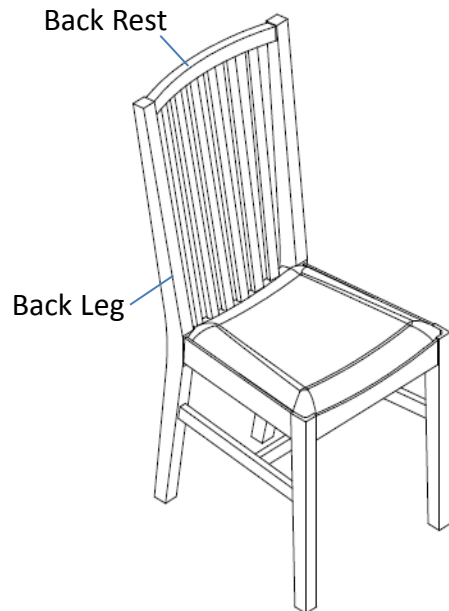
Further typical bentwood application

- Bentwood is flexible and shock-resistant



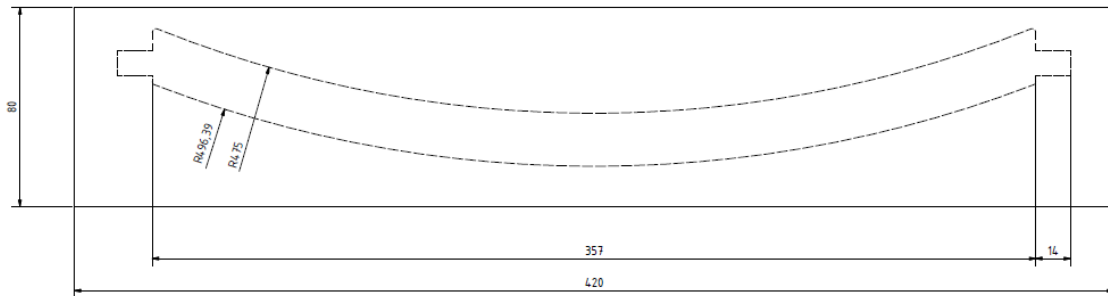
- Bentwood toboggans and sledges are typically made from Ash, Beech.

- Typical Chair:

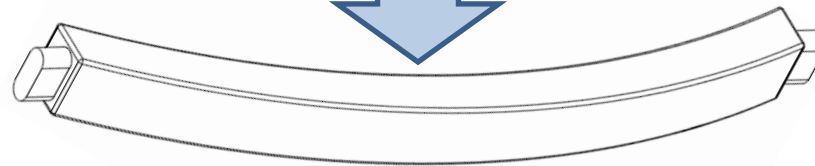


1. Non- Bending Production:

1.1 Back Rest



Milling / mortising from board

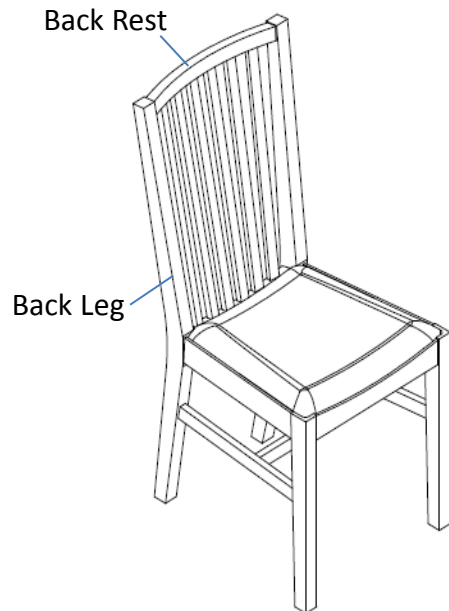


Yield: approx. 25%

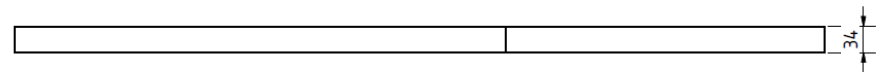
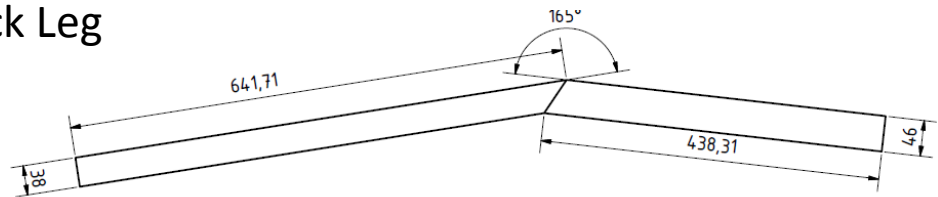
Board: $8 \times 42 \times 3,3 \text{ cm}^3 = 1.109 \text{ cm}^3$

Part: $2,3 \times 38 \times 3,1 \text{ cm}^3 = 271 \text{ cm}^3$

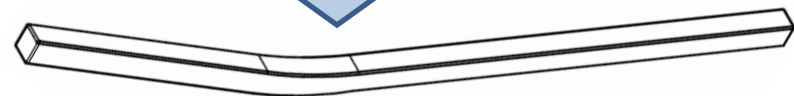
- Typical Chair:



- Non- Bending Production:
 - Back Leg



2 pieces cutting & bonding,
milling to shape



Yield: approx. 64%

upper: $3,4 \times 64,2 \times 3,8 \text{ cm}^3 = 830 \text{ cm}^3$

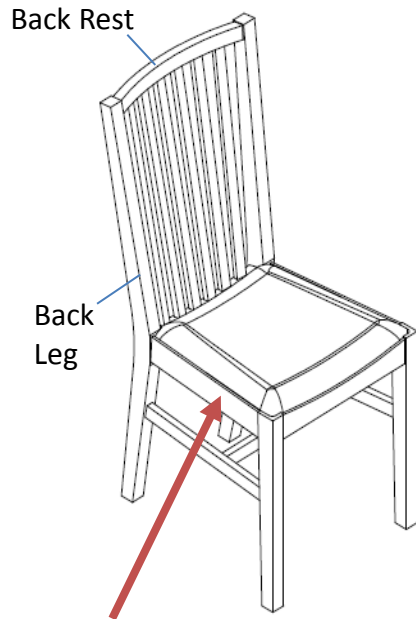
lower: $3,4 \times 43,9 \times 4,6 \text{ cm}^3 = 687 \text{ cm}^3$

total: 1.517 cm^3

back leg: $3,0 \times 101,5 \times 3,2 \text{ cm}^3 = 975 \text{ cm}^3$

Bending Practice (3)

• Typical Chair:



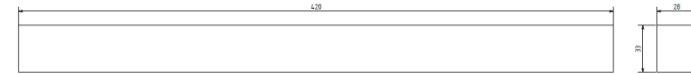
Further improvement by *design for bending* (e.g. bended chair Frame in U-shape and smaller cross-sections of legs) increase the yield and cut assembly time.

2. Bending: 2.1 Back Rest

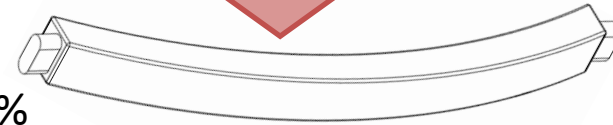
Yield: approx. 66%

workpiece $2,8 \times 42 \times 3,5 \text{ cm}^3 = 412 \text{ cm}^3$

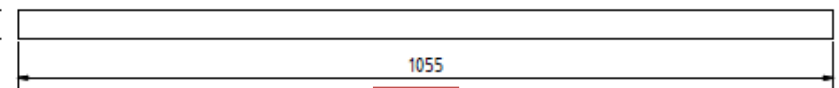
back rest $2,3 \times 38 \times 3,1 \text{ cm}^3 = 271 \text{ cm}^3$



cutting \Rightarrow bending
 \Rightarrow milling / mortising



2.2 Back Leg



cutting \Rightarrow bending
 \Rightarrow milling / mortising



Yield: approx. 76%

workpiece $3,4 \times 105,5 \times 3,6 \text{ cm}^3 = 1.290 \text{ cm}^3$

back leg $3,0 \times 101,5 \times 3,2 \text{ cm}^3 = 975 \text{ cm}^3$

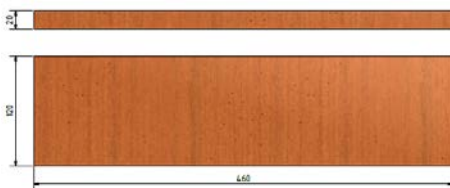
Bending Practice (4)

- Bowl, Ø 290 x 145 mm

- Bending



Sample made from
Walnut
Maple

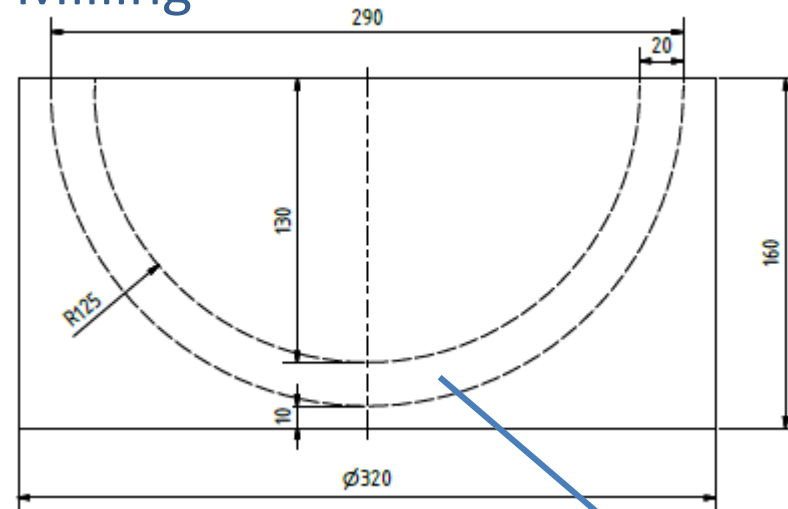


Material used:

5 boards: $46 \times 12 \times 2 \text{ cm}^3 = 5.520 \text{ cm}^3$

Yield approx. 41,6 %

Milling



Volume $\approx 2.300 \text{ cm}^3$

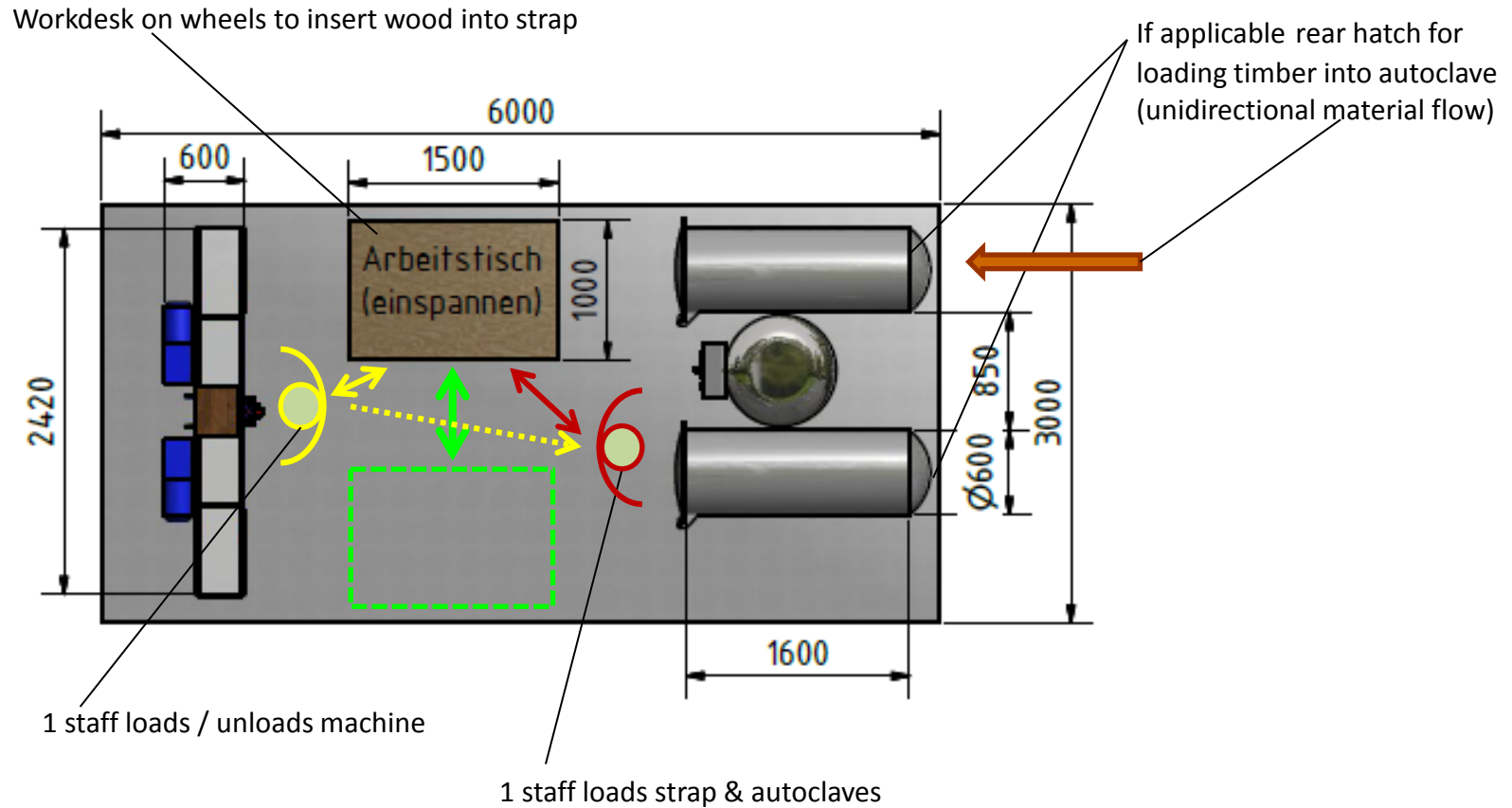
Material used:

1 block $\text{Ø } 32 \times 16 = 12.868 \text{ cm}^3$

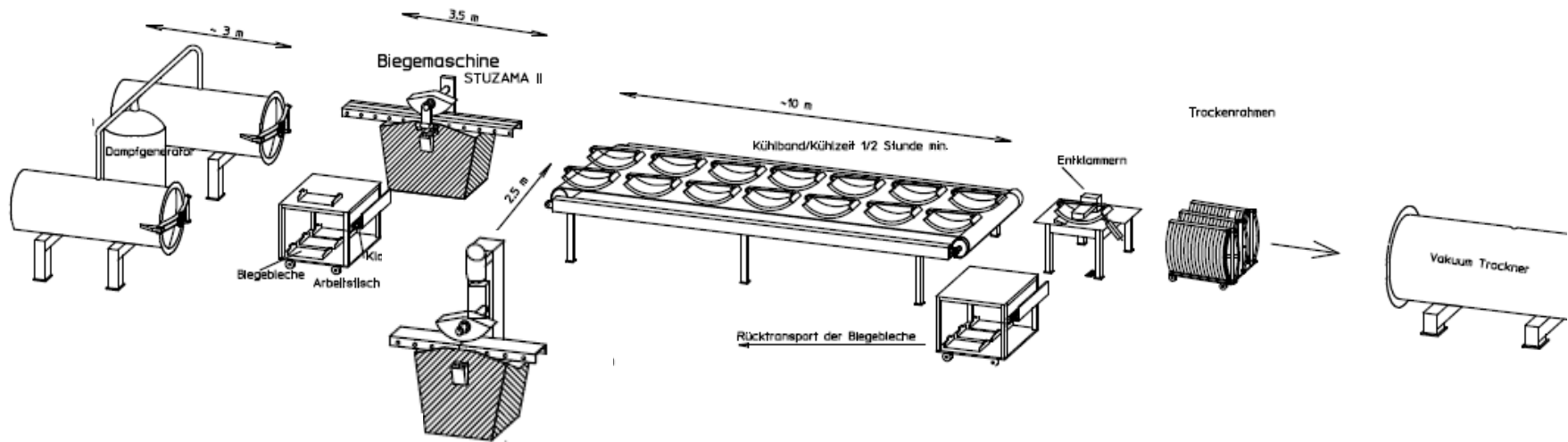
Yield approx. 18 %

- Dimension of.. timber (lwh), e.g.: 1200 x **60** x 30 mm³
- Max. operating width, e.g. Stuzama II: 300 mm
 - 5 pcs. of timber can be bent in one go
- Cycle time / bending approx. 20 ... 60 s (machine, angle)
- Softening equipment:
 - Time for steaming $\approx 1 \dots 2$ min / mm (initial moisture content?)
 - E.g. @ 30 mm: softening $\approx 30 \dots 60$ min
 - Number of autoclaves $\geq t_{\text{softening}} / t_{\text{bending}}$
- **Detailed planning of bending plant by supplier**

Flexible Production Cell



Bending Plant



Bending plant for high volume production, featuring:

- two-door autoclaves for unidirectional material flow
- mobile work desk with strap & clamp holder
- 2 bending machines Stuzama VP & II, incl. 1 counter bending device
- stabilizing conveyor
- unclamping section
- Drying carriages

- Production:
 - ✓ Yield usually $\geq 66\%$ \Rightarrow low waste, less material costs
 - ✓ quick process \Rightarrow high output
 - ✓ versatile bending equipment
- Design:
 - ✓ light look and feel but high durability
 - ✓ slim design favoured
- Properties
 - ✓ long lasting, durable products of high quality
 - ✓ no splintering when breaking

Thank You

Information videos available at
<http://www.youtube.com/user/GHEbavaria>

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