

Bentwood Chair Production a stunning production system

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Contents

Bentwood Chair Production - a stunning production system

- **1** GHEbavaria Maschinen GmbH Solid Wood Bending Systems Supplier
- 2 Solid Wood Bending
- 2.1 Introduction
- 2.2 Applications from past to present
- 2.3 Actual Market Situation and Outlook
- 2.4 Scientific Approach, Damages, Visco-elastic behaviour

3 The Thonet Production System

- 3.1 Production Systems- a brief Introduction
- 3.2 The Thonet Process
- 3.3 Results of the Thonet Production System

4 Conclusion



<u>GHE bavaria</u>

1 GHEbavaria Maschinen GmbH

GHEbavaria – Solid Wood Bending Systems Supplier

- Family operated, established 1870 by Hofmann br. (great grandfather)
- Today main business *Solid Wood Bending* equipment
- Further activities in renewable energies
- Bending machines for open (U) and closed (O) shapes
- Softening plants: steam generator & autoclaves
- Export worldwide
- from: Eibelstadt / Würzburg, S-Germany









2.1 Solid Wood Bending – Introduction (1)

Tensions in Bentwood

- Wood allows tensile elongation only to $\approx 1,5\%$
- Further elongation causes breaking
- Softened Wood: Compression uncritical
- System of Metal Strap with End Stops & Softend Wood (*Thonet Method*)

 Tensile Stress covered by Strap

o Compression Stress to densify softend wooden cells



Fig. a) General Bending







2.1 Solid Wood Bending – Introduction (2)

Softening

- Initial moisture, optimum: 18% ± 2%
- Saturated steam, T \approx 102 °C, P \approx + 0,2 bar, t \approx 1min/mm

Bending

 Bending ratio s = ^r/_d depending on wood species (degree of tolerated densification)

Stabilizing

- 1. $t \approx 30 \dots 90$ min with strap & clamp
- 2. Drying in frame to H < 12%
- 3. No more spring-back (see Norimoto)







2.1 Solid Wood Bending – Introduction (3)





2.2 Solid Wood Bending – from Past to Present (1)

Wood Bending Applications of the Past:

- Barrels
- Chairs
- Sleighs (and related)
- Frames of many kinds:
 - o Suitcases
 - Ships (vertical frames)
 - o Airplanes (wood constructions until 1950ies)
- Wheel rims, steering wheels etc.















2.2 Solid Wood Bending – from Past to Present (2)

Wood Bending Applications of the Present:

- Chairs
- Sleighs (tobbogans, luges, ...)



Special products,
 e.g. Dining Table made of Barrel Segments (bent back to flat)









2.3 Solid Wood Bending – Actual Market Situation and Outlook

Actual Market Situation:

- Products: chairs (worldwide), sleighs (alpine countries)
- Emerging Markets:
 - increasing demand because of high material yield
 - very little knowledge of solid wood bending
 - interesting markets
 - o Asia: China, India, Turkey, Malaysia, Vietnam
 - Americas: Brazil (USA- relocating production back from China)
- Design trends:
 - Fashion trends, competing steel & wooden chairs (up & down)
- Outlook
 - constant demand for bending plants to continue on low level
 - Thonet designs still demanded by customers





2.4 Solid Wood Bending – Scientific Approach

Solid Wood Bending was the subject to many research topics over the years, in particular between 1920ies to 1960ies, focussing on

- Softening treatment (steam properties) and
- Bending behaviour / bending properties (densification, radius / thickness, wood species, damages).
- Résumés can be found in [Egg95] and [Ste70].
- Stabilizing / drying of bent-parts not so much in focus over the years





2.4 Solid Wood Bending – Damages

Bending Damages:

- Only 2 reasons for bending damages:
 - Process to allows elongation during bending
 - o process allows elongation to more than 1,5 %
 - o part does not fit tight in strap or
 - elastic spring back during stabilisation phase
 - o splintered fracture
 - Softening process not well adapted
 - Moisture content outside of 10 ..18 .. 20 % as of 10 % for wide open bending, ⁺/₋ 18 % for narrow bending / high densification
 - Temperature outside of 85 .. 105 ..120 °C
 - o Cell collapse









2.4 Solid Wood Bending – Damages

Bending Damages:

- Leading producer (since 1860ies):
 - Overall scrap rate of less than 0,3% in 2012



Picture taken from noticeboard in bent-shop, Nov. 2013





2.4 Solid Wood Bending – Visco-elastic behaviour (1)

Visco-elastic behaviour of bentwood during stabilisation



Wood Bending - Compression Stress





2.4 Solid Wood Bending – Visco-elastic behaviour (2)

Behaviour suggests similarities to Burger-Kelvin-Model







3.1 Production Systems – Introduction (1)

According to Toyota Motors, a Production System consists of two major parts:



Fig.: Toyota Production System for 21st century





3.1 Production Systems – Introduction (2)

People – 3 criteria:

- Can (skills & know how)
- Want (motivation)
- To be empowered (position, job description, legal framework)

Idea behind: it's the people who drive the processes





3.1 Production Systems – Introduction (3)

The Process- Part of the Production System can be regarded like this:



A production system is the joint effort of all members in the process to reach the one target: Satisfying the customer's needs.

If one parts fails, the whole thing can't work.





3.2 Production Systems – The Thonet Process (1)

Michael Thonet, 1796 – 1871, German cabinet maker

- 1841 moving from Boppard / Rhine to Vienna
- 1841 `49 Tests, how to produce curved parts
 - Laminating not working, glue not satisfactory disolve
 - Bending not working, break on outside
- 1849 developing solid wood bending by using a metal strap outside (Thonet Method)
- 1859 designing chair Thonet No. 14
 - Modular design for making multiple versions
 - First mass product of industrialisation
 - Until 1914 > 50 mio. produced









3.2 Production Systems – The Thonet Process (2)

Why the production of the chair No. 14 can be regarded as a production system:

- 1st focus: Production method Wood Bending to produce chairs
- Product specifically designed for this production method
- Product designed for low production costs (Marketing-M. Thonet: low priced consumer product)
- Own distribution channel (sales)
- Chair sold disassembled in box for low shipping costs (Logistics)





3.3 Results of the Thonet Production System

50 years after the launch of Chair No. 14 (1910):

- 3 production companies (Thonet, Kohn, Mundus)
- 21 plants
- more than 50 mio. chairs no. 14 built
- Wide variety of bentwood chair designs, e.g. "Postsparkassenstuhl" (Postbank-chair, designed for the new building in Vienna by architect Otto Wagner)

Today:

• Bentwood plants on every continent all over the world





4 Conclusion

- Solid Wood Bending Process: widely understood.
- Application: shifted back to mainly chairs after a period of versatile use.
- Resource- effective method, using sustainable material.
- Wider spreading prevented by lack of process know-how.
- Present R&D activities to optimize stabilisation phase.
- Michael Thonet & his sons covered ALL aspects of a modern production system already in 1861 with the start of his first plant in Bistřice. Still, Thonet is not acknowledged in literature on industrial production like Henry Ford or Toyota.



Contact



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Appendix

Literature (brief overview):

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