Design and manufacturing large scale diffusion bonding hot presses

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(PVA TePla Group)
Vakuum systems and contract services for heat treatment of High-End Materials:

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Headquarter, assembly and contract service workshops (Wettenberg, Germany)
THE PVA TEPLA DIFFUSION BONDING “TASK FORCE”
AGENDA:

I. Overall design procedure

II. Pressing System
   A) Multicolumn designs
   B) Methods
   C) Materials Data
   D) Control system

III. Heating System

IV. Manufacturing
I.) Design Procedure
**Product driven bottom up design:**

- The defined product portfolio dictates the sizing and the complexity
- Customer requirement input

- Vacuum pumping unit
- Pressing unit
- Gas, liquid and power connection
- SPS/Hardware

- Cold wall stainless steel
- Doors, flanges and feed-throughs

- Heaters and thyristors
- Thermal couples
- Cooling system

- Force distribution system
- Measurement systems (Load and positioning)
II.) Pressing System
LARGE SCALE DIFFUSION BONDING

LOAD:
- If the size of the part is bigger than the ram size → load is lower on the boarders of the part.
- Bonding not sufficient.
- Risk of distortion.

TEMPERATURE:
- Excessively higher dwell times have to be considered.
- Microstructural differences between outer and inner part (e.g. grain growth).
- Residual stresses

TEMPERATURE-LOAD-INTERDEPENDENCE:
- Yield-strength is a function of temperature.
- Non uniform joining results
Multicolumn design:

- Reduction of the overall inhomogeneity of the force distribution
- Less thermal mass in the furnace, thus effective heating and cooling
- Size is limited only by the available pressing plates

800 x 600 x 400 mm³  1000 x 900 x 480 mm³  1500 x 600 x 500 mm³
Development of columnar designs:
With Large-Scale systems, the deciding factor is the stiffness of the pressing plates and pillars.

Starting point of design is the part size and material as well as customer specifications.

Calculation/Implementation of the necessary force via numerical simulation (FEM) becomes unavoidable.
Experimental:

- Thermogravimetric analyses of the decomposition and/or melting
- Microstructural analyses using a SEM (Usually in backscattered mode for material contrast)

Results

- Decomposition under Vacuum above 1400°C indicating metallic or silicon impurities
Experimental:
- LCF testing under compression

Results:
- Force needed to delaminate one isolated pillar = 800 KN
- Maximum compression stress = 148 MPa
- Youngs modulus = 86.2 Gpa
- Due to laminated structure anisotropy effects occur (Different compression on different positions around the circumference)
- Very low ratcheting or creep effects
**Control of the pressing – measurement:**

- Two main values – applied force and position of the pressing plate
- Transformation from the calculated force (based on the hydraulic pressure of the system) to direct measurement using load cells (precision and safety).
- Due to modern positioning sensors a measurement with a resolution ~1 µm becomes possible (until now ~10µm)
- Operating strategies:
  - Force controlled systems (standard)
  - Position controlled (absolute/relative)
  - Combined force-position controlled

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III.) Heating and cooling
HEATING SYSTEM:

**Mo-Heated:**
- Hydrocarbon-free high vacuum atmosphere possible.
- Highest flexibility of possible materials to bond (Ti, highly alloyed steels, Ni-based super alloys).
- More complex and more expensive heating set-up.

**Graphite/CFC-Heated:**
- High vacuum atmosphere possible.
- Usable for robust processing, thus for serial and mass production.
- Less complex and less expensive.
IV.) Manufacturing
“Bottleneck” structures have to be treated with special attention (Heaters, Vessel and Doors, Force distribution system).

- Periphery manufacturing/buying can be delayed or pre-prepared
- Assembly phase
- Factory acceptance
Thank you for your attention!

Questions?