



HoD  
*forming*

# HDF – fast **Hot Die** forming

by active material blank feeding

The revolution in extreme lightweight metals forming

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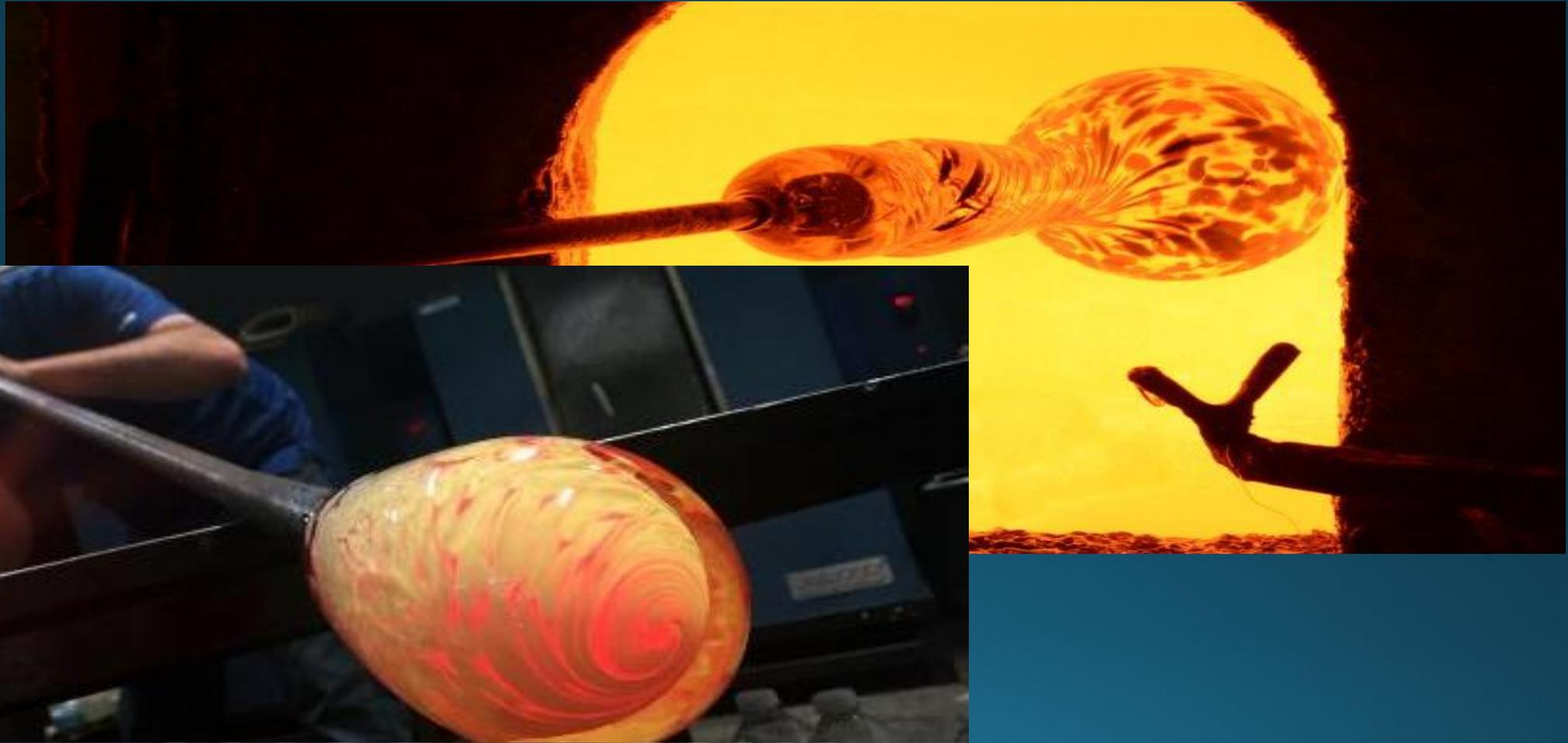
Shown member was developed and manufactured by Dr. Amborn in the mold of his previous HEATform GmbH

# About the HoDforming GmbH...

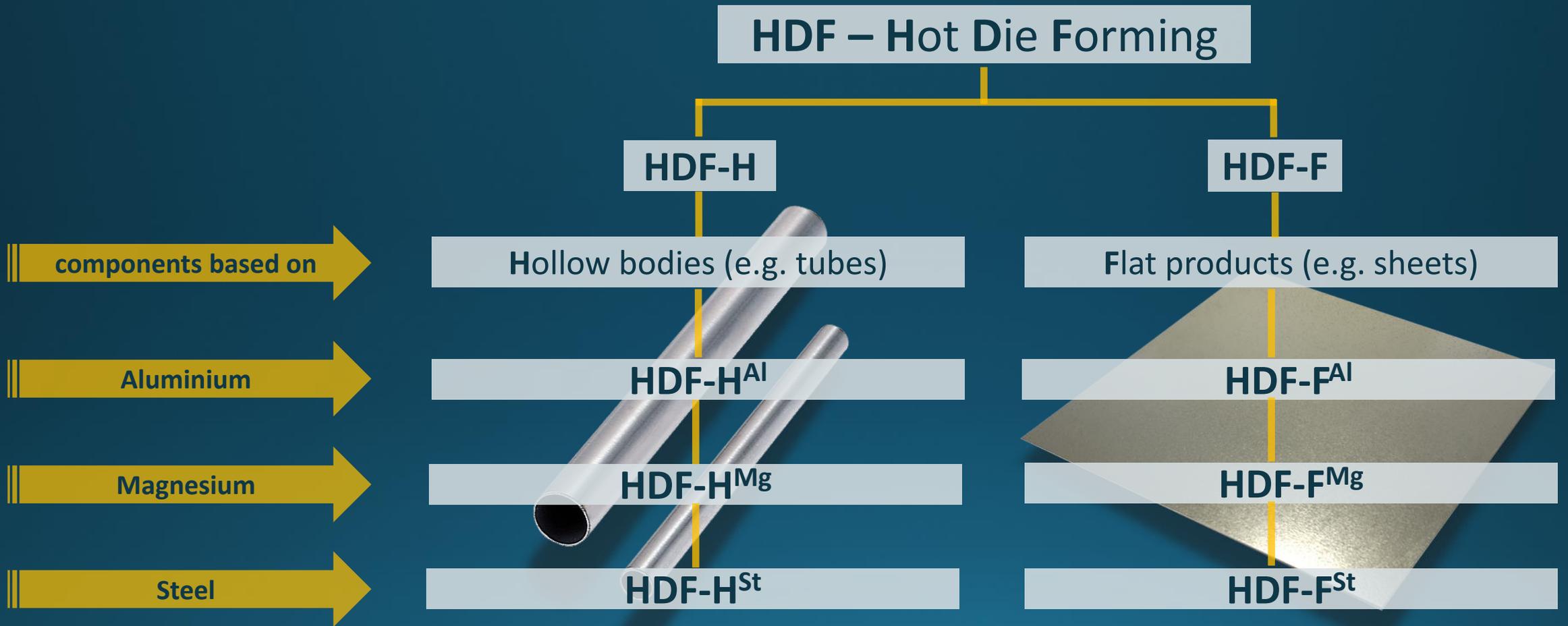


- HoDforming GmbH focusses especially on **high-temperature forming - at best possible advanced temperature** - of metals such as **high strength aluminium or magnesium**.
- HoDforming GmbH offers a unique and cost efficient **HOT-Die forming** technology which is proven in **high volume production**.
- The **forming tools as well as the blank** are **advantageously tempered** and the **blank is actively feeded** into the cavity.

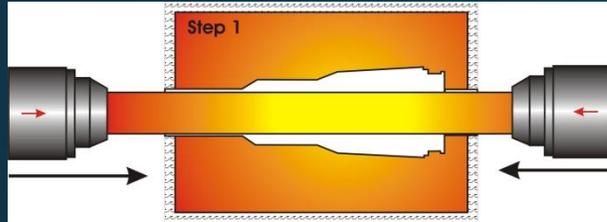
# Why forming in hot condition...



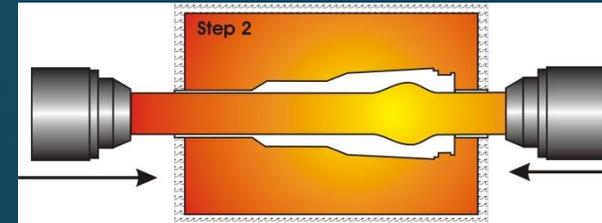
# HDF Technology Portfolio



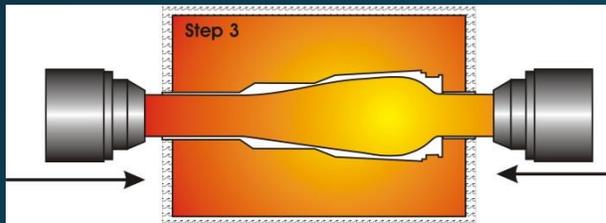
# HDF-H principles e.g. tube



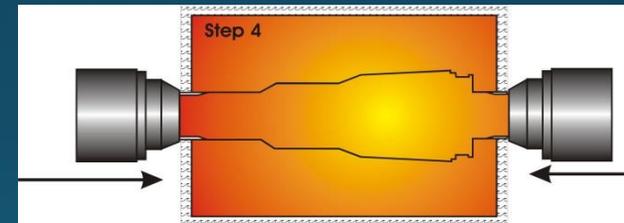
A tube is heated up to an adequate temperature profile, then is placed into an adequately heated die and sealed at both ends.



A tube is blown up by putting it under gas pressure and deformed with material supply pushed in from both ends (= constant volume!)



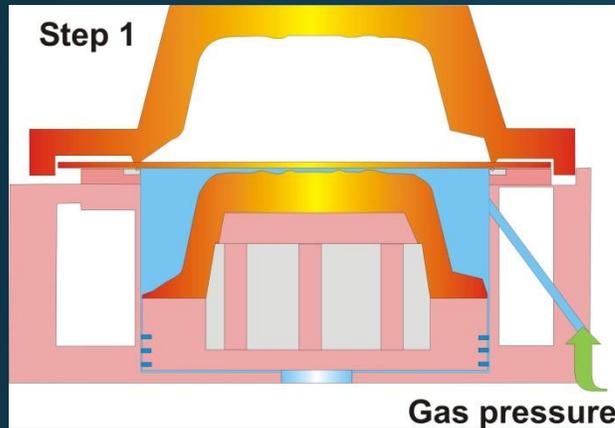
The positioning of material under hot gas pressure with material supply pushed in from both ends defines the final (local) tube thickness



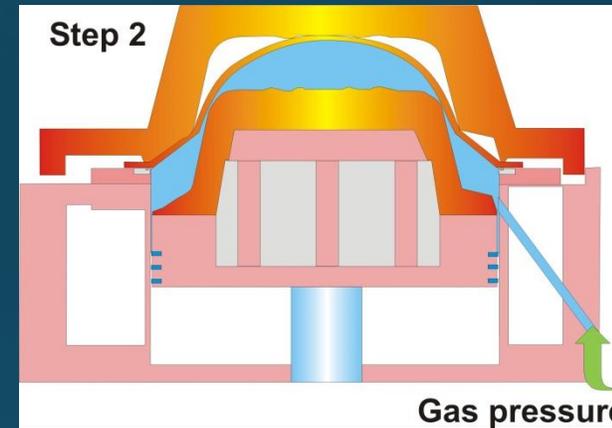
The tube is finally calibrated under the inner hot gas pressure, achieving the final shape and exact tool dimensions.



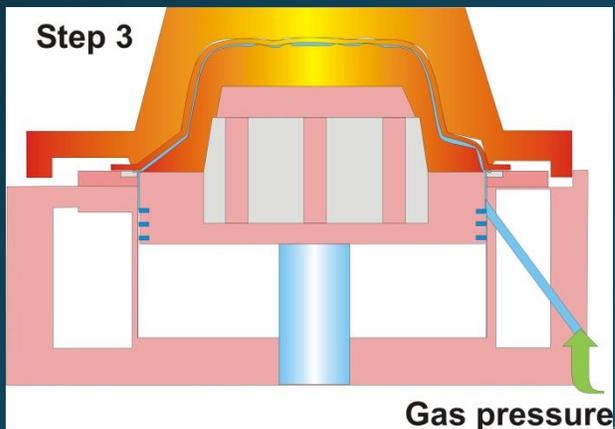
# Schematic HDF-F process



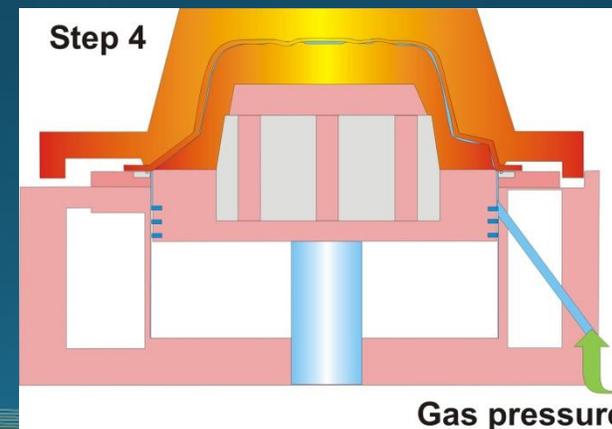
- Positioning of sheet
- Closing the tool
- Initialize gas pressure



- Increase gas pressure
- Piston moves up words, reducing gas volume
- Controlled material intake

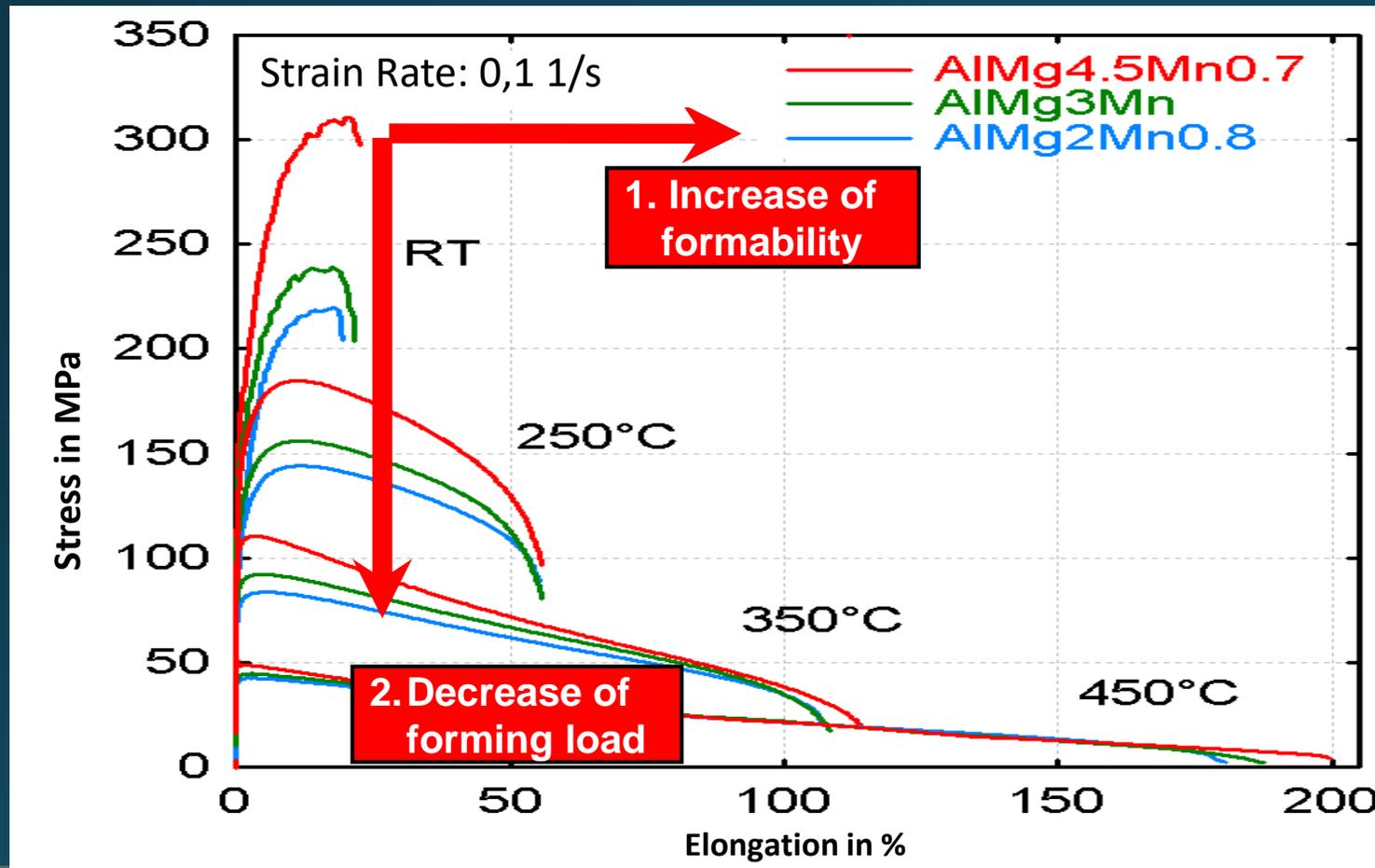


- Constant gas pressure
- Piston moves up further, increasing gas pressure
- Controlled material intake



Optional:  
The sheet rims are fixed, no material intake possible!  
The piston motion generates final shape (incl. small radii), increasing gas pressure to smoothen surface wrinkles

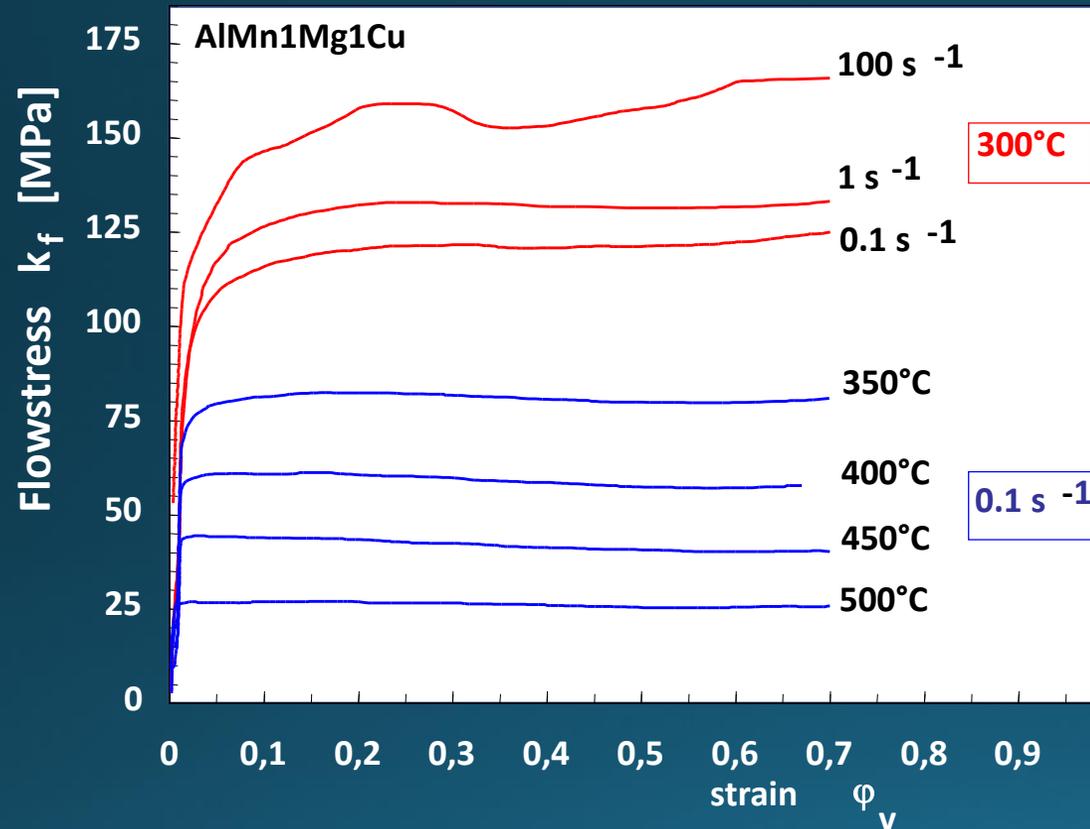
# Effect of temperature on stress/strain behavior of ENAW5083 (Al-Mg-Mn) alloys



Effects of Temperature and Strain Rate on Strength and Formability :

$R_{p0.2} \searrow$ ,  
 $r\text{-Wert} \rightarrow$ ,  
 $n\text{-Wert}$  and  $A_{\text{uniform}} \searrow (!)$ , but  $A_{\text{max}} \nearrow$   
due to  $m \nearrow !$

# High Temperature Flow Stress in Al Alloys

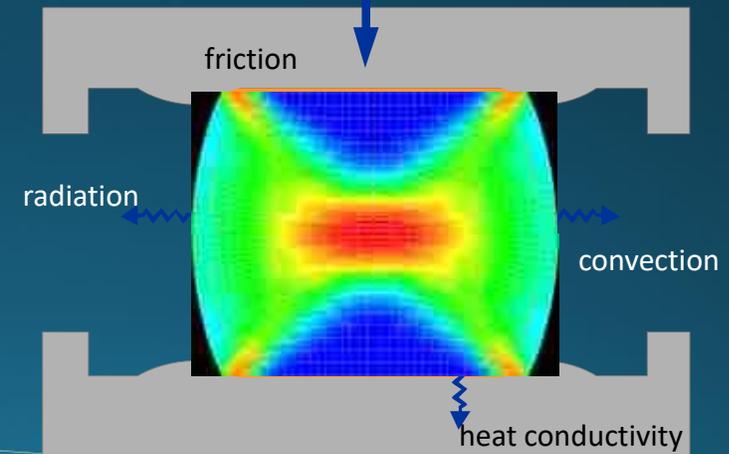


Quantitative description :

$$k_f = \frac{1}{\alpha} \cdot \sinh^{-1} \left( k \cdot \phi_v^{m_1} \cdot e^{m_2 \cdot \phi_v} \cdot Z^{m_3} \right)$$

Zener – Hollomon – Parameter

$$Z = \dot{\phi}_v \cdot e^{\frac{Q_{def}}{R \cdot T}}$$



# Hot Forming Mechanisms in Al-Mg alloys

## Superplastic Forming (SPF)

*Utilizes GBS deformation*

## Quick-Plastic Forming (QPF)

*Utilizes the transition region between GBS and SD deformation; considered a "Hybrid" process*

## Solute-Drag Forming (SDF)

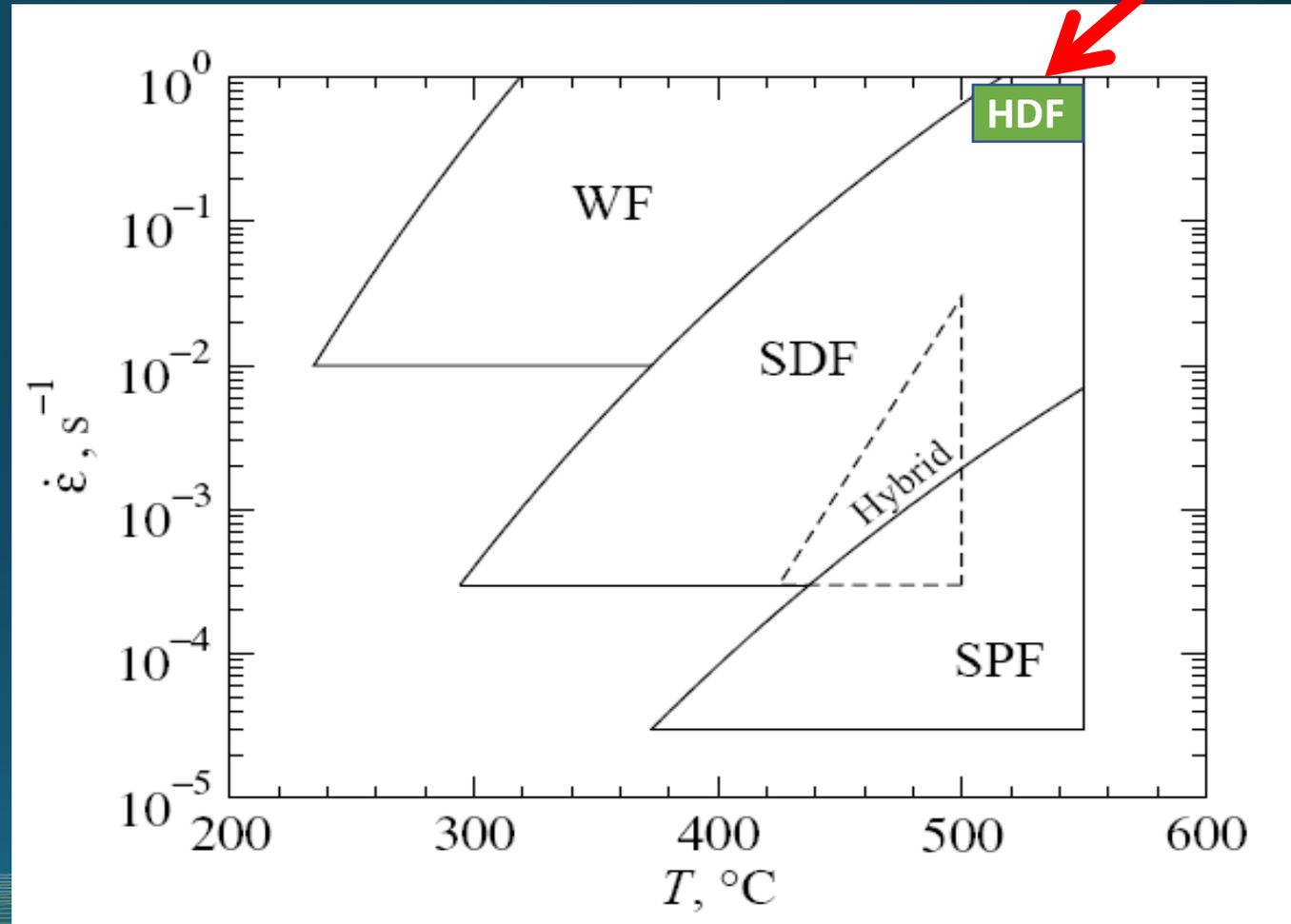
*Utilizes SDF deformation*

## Warm Forming (WF)

*Utilizes deformation from SDF well into PLB-creep*

*Ref. Eric M. Taleff*

*The University of Texas at Austin*



# HoDforming characteristics I

- **Ability to form every metal component** - which is not formable in cold condition
- **Ability to form a hollow body or a component made from a sheet blank)** - in every condition
- **low forming forces** - 10 times less than cold formed are needed
- **stable forming process** - almost no scrap
- **CO<sub>2</sub> friendly** - due to no required pre-heat treatments and low forces
- **Cost efficient process** - low cost forming dies
- **low or high component volume** - can be produced cost effective
- **thin sheets - complex geometries,** small radii or sharp edges

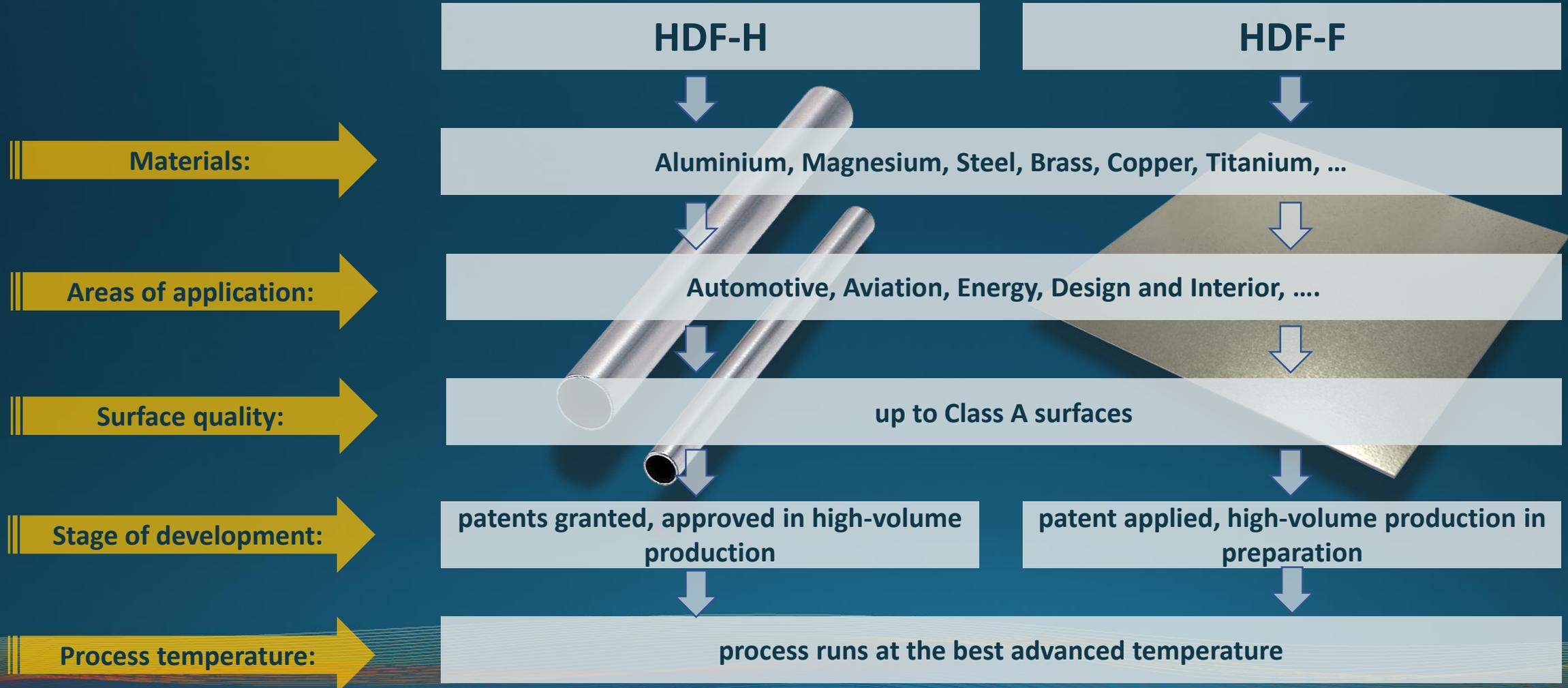
# HoDforming characteristics II

- **wrinkle free components** - due to the possible high gas pressure
- **reduction of welding connections** - less parts needed
- **possibility to form tailored blanks**
- **complex components** - with a defined wall thickness distribution less than 20%
- **A-Class surface** and eye-catching shapes possible

# HoDforming is able to offer ...

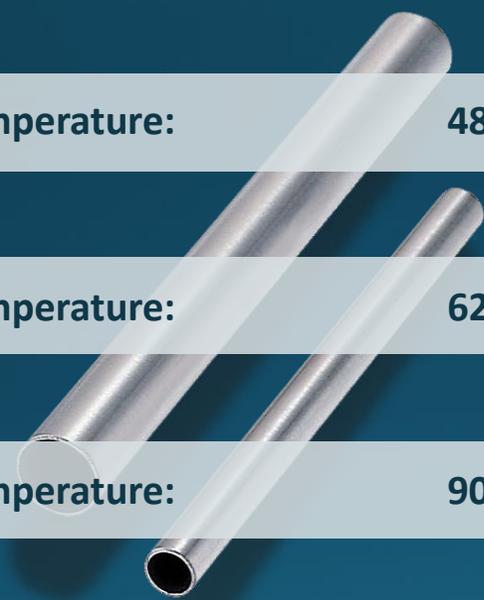
- a working technology with a **permanent HOT-Die** at **best possible advanced temperature** which is already proved by high volume production.
- a forming of **metal sheets and blanks at best possible advanced temperature**
- an **actively feeding** of the blank **into the cavity**
- an efficient process where components can be produced in **less than 20 seconds cycle time**
- forming of the blank **by gas** as **forming medium** or **by punch** or in **combination of both**

# HDF-Technology Portfolio for forming...



# HDF-H „Die temperature“ in °C...

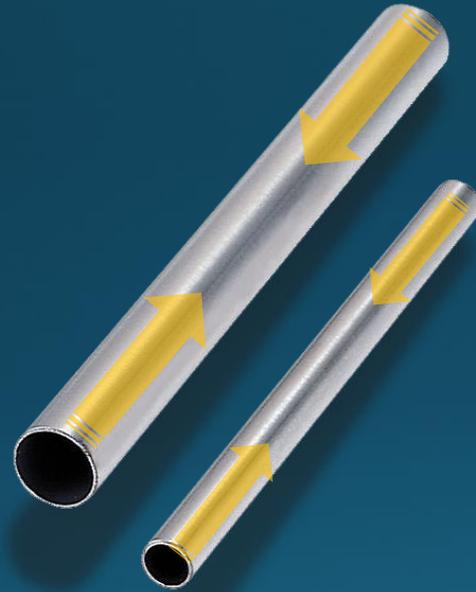
The already high volume proved HDF-H process uses a permanent “Hot-Die” (at best possible advanced temperature).

Two aluminum tubes are shown in the center of the table, one slightly behind and to the right of the other, both pointing towards the right.

|                                  |                               |   |
|----------------------------------|-------------------------------|---|
| <b>Aluminium:</b>                | Die temperature: 480 – 550 °C |    |
| <b>Brass</b>                     | Die temperature: 620 – 850 °C |    |
| <b>Mild Steel:</b>               | Die temperature: 900 – 960 °C |   |
| <b>Ferritic Stainless Steel:</b> | Die temperature: 950 °C       |  |

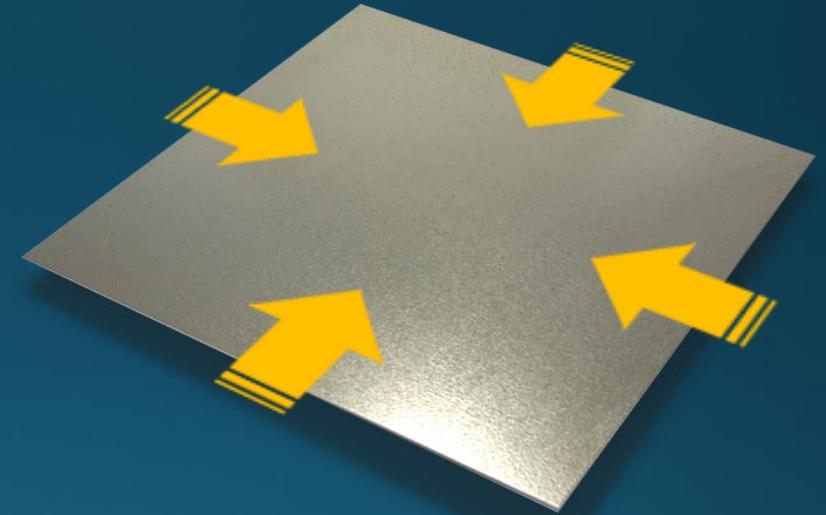
HDF means that the **blank can be actively feeded** in the cavity....

HDF-H



absolutely friction free

HDF-F



low determined friction

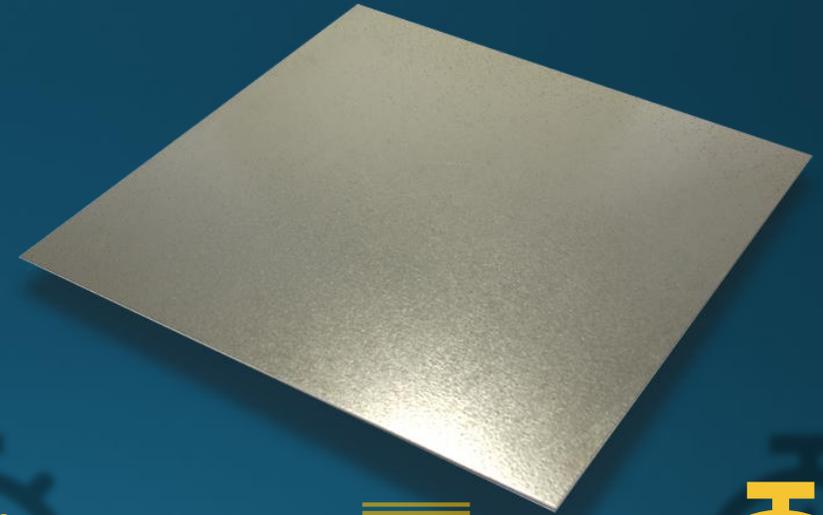
HDF is a **time efficient** process where components can be produced in

HDF-H



less than 40 sec. cycle time

HDF-F



less than 20 sec. cycle time

# HDF uses **gas and/or a punch** as **forming medium**

HDF-H

HDF-F

A-Class components:

should be formed by gas pressure

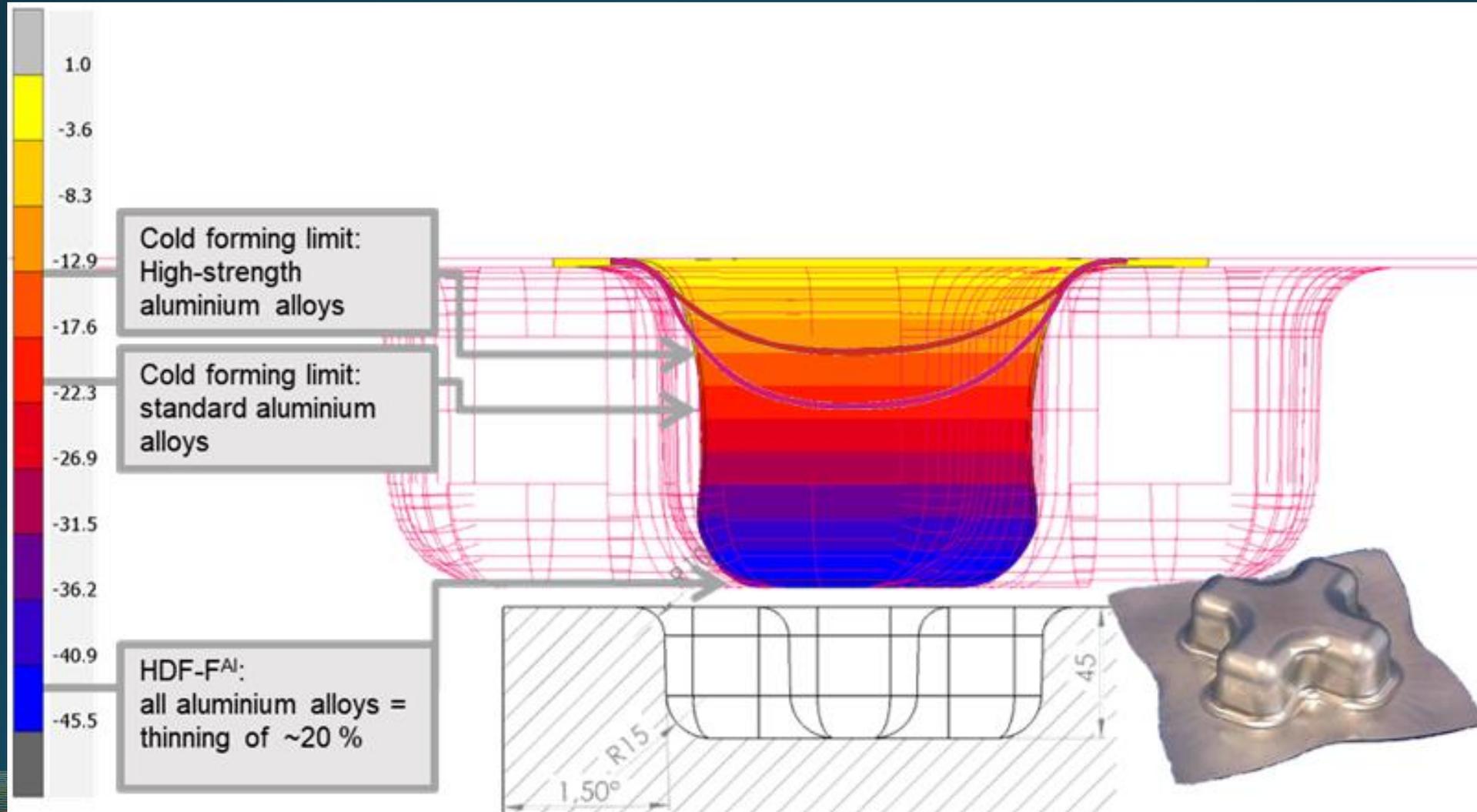
Structure components:

can be formed by punch

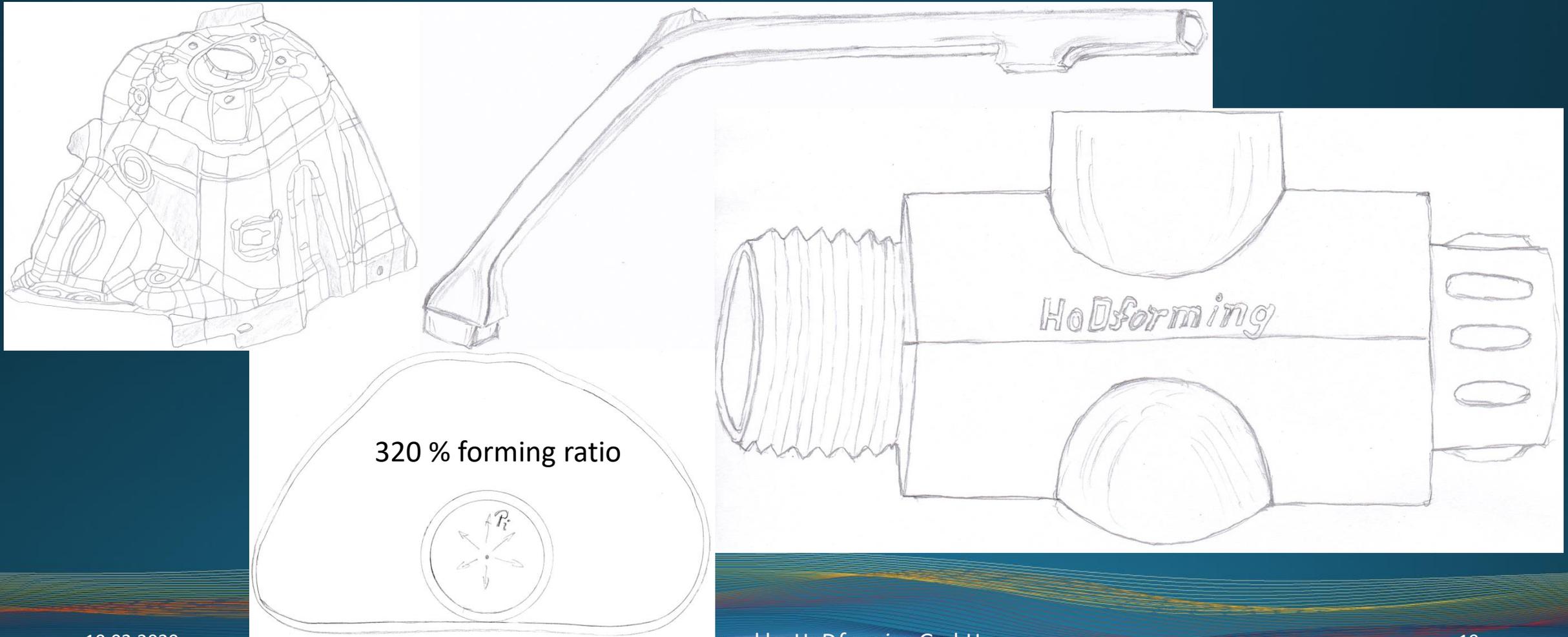
Wrinkle free structure components:

should be formed by punch and gas

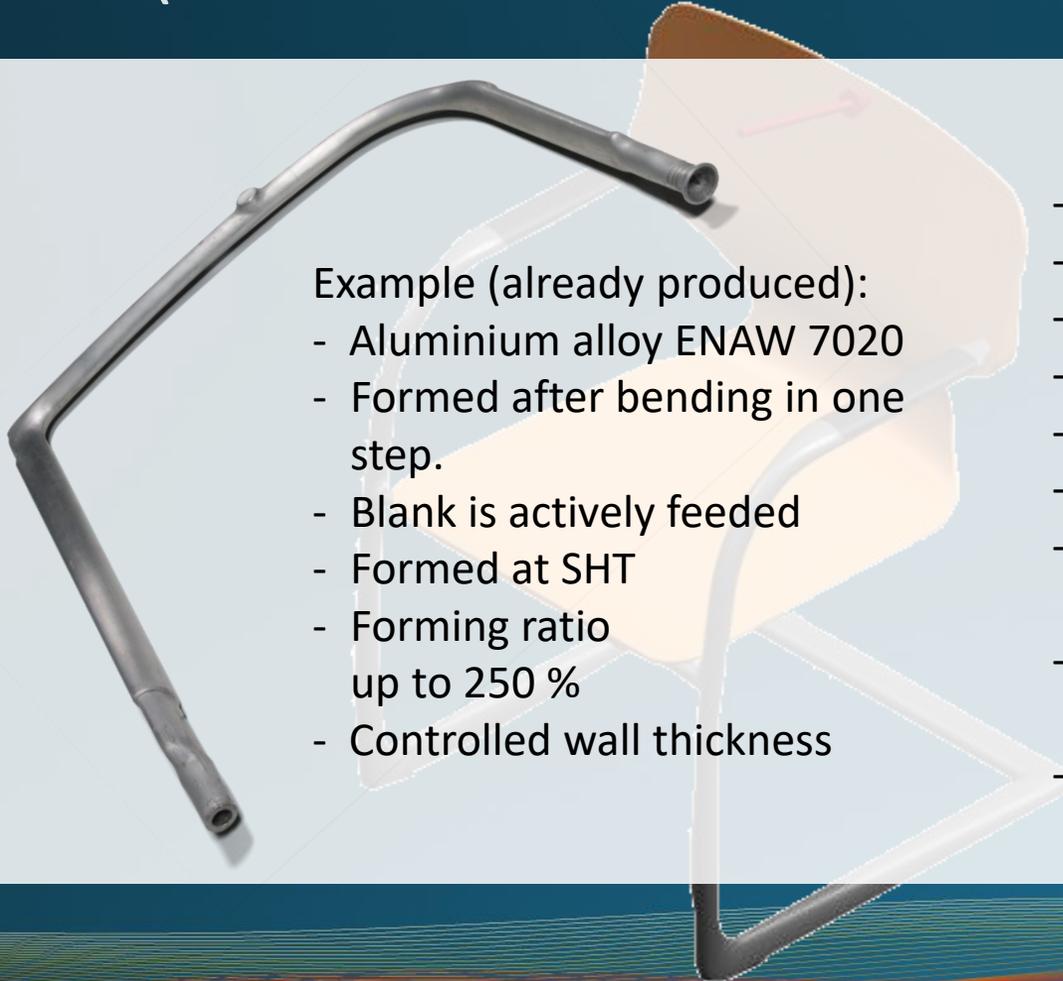
# HDF-FAI Limits of conventional cold forming



# Potential HDF - Products (HDF ENAW Xxxx)...



# Potential HDF - Products (HDF-H & HDF-F ENAW 7xxx)...

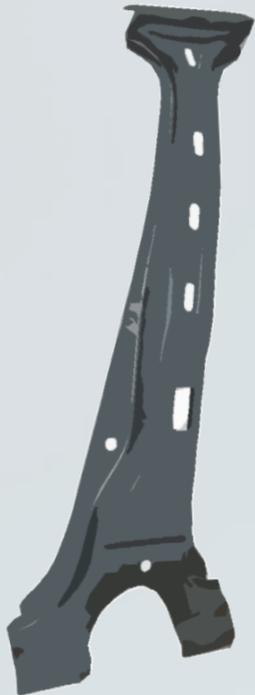


Example (already produced):

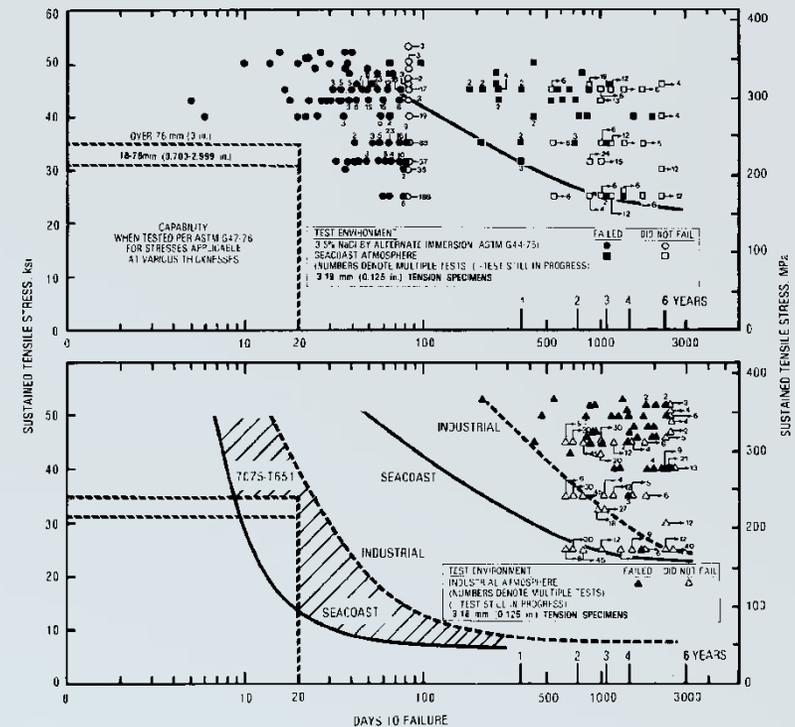
- Aluminium alloy ENAW 7020
- Formed after bending in one step.
- Blank is actively feeded
- Formed at SHT
- Forming ratio up to 250 %
- Controlled wall thickness

- Forming aluminium and magnesium alloys **in one step**
- Forming of ENAW 7xxx alloys **without any heat treatment**
- No spring back effect
- High accuracy
- Wrinkle free
- Controlled wall thickness
- Using of Tailor Welded Blanks (TWB) or Tailor Rolled Blanks (TRB)
- Using different Aluminium and Magnesium alloys connected in tailor welded blanks
- Using of material reinforcements within process

# Potential HDF-F - Products B-Pillar (e.g. ENAW 7075)...



- Blank will be coated with special lubricant
- Blank will be heated up (e.g. two heating stations for sheet thickness >2 [mm])
- forming the B-Pillar by punch
- cooling rapidly down in fixed position
- probably a heat treatment T73651 could be necessary due to the stress corrosion cracking (SCC or hydrogen cracking), see treatments for screws with > 400 MPa



# HoDforming at a glance...

- **HoDforming** is a technology for advanced aluminum, magnesium, steel and metals forming
- All advantages of the forming capabilities can be realized for extremely light weight constructions
- The innovative technology is able to realize extreme light weight products in a most efficient way, as e.g. relevant in the automotive industry
- Realizing of forming complex geometries in combination with high strength alloys
- New possibilities to optimize the crash worthiness of the products
- Cycle time for the main automotive products is less than 30 seconds
- Forming ratios up to 200%
- Small radii as well as sharp edges possible
- Class A surface realisable
- Active blank material feeding in the cavity

# Thank you for your attention

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